1966

Yield and Chemical Analyses of Fruit Produced by Selected Deer-Browse Plants in a Loblolly-Shortleaf Pine-Hardwood Forest.

Eugene Frank Hastings
Louisiana State University and Agricultural & Mechanical College

HASTINGS, Eugene Frank, 1928-
YIELD AND CHEMICAL ANALYSES OF FRUIT PRODUCED BY SELECTED DEER-BROWSE PLANTS IN A LOBLOLLY-SHORTLEAF PINE-HARDWOOD FOREST.

Louisiana State University, Ph.D., 1966
Agriculture, forestry and wildlife

YIELD AND CHEMICAL ANALYSES OF FRUIT PRODUCED BY SELECTED DEER-BROWSE PLANTS IN A LOBLOLLY-SHORTLEAF PINE-HARDWOOD FOREST

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The School of Forestry and Wildlife Management

by
Eugene Frank Hastings
B.S.F., Louisiana State University, 1953
M.S.G. Mgt., Louisiana State University, 1954
August, 1966

ACKNOWLEDGEMENT

The writer wishes to take this opportunity to express appreciation to those who assisted in this study and in preparation of the manuscript. Without the loyal support and aid of my wife, Elizabeth, the completion of this work would have been most difficult. My graduate committee, Drs. Bryant A. Bateman, Paul Y. Burns, Clair A. Brown, Leslie L. Glasgow, and Thomas Hansbrough, gave valuable assistance in organizing the study and in preparing this manuscript. Mr. John D. Newsom, Leader of the Louisiana Cooperative Wildlife Research Unit, was always willing to help when problems arose, and his advice and suggestions are greatly appreciated.

This investigation was possible because of a research assistantship grant by the U. S. Forest Service to Louisiana State University. The U. S. Forest Service also provided the land on which the investigation was made. Expenses which occurred in developing and maintaining the area were shared by the U. S. Forest Service and Louisiana Wild Life and Fisheries Commission. Messrs. Lowell K. Halls and Robert M. Blair, U. S. Forest Service personnel, assisted in planning the study and provided valuable information about the study area.

Mr. E. A. Epps, Jr. and staff of the Louisiana State University Feed and Fertilizer Laboratory provided the equipment and assistance necessary to determine the proximate analyses of the fruit. The advice of Dr. Barton R. Fathing in the statistical design and analyses was very helpful. The personnel of the Louisiana State University Computer

Research Center processed the data through the computer. Mr. S. A. Lytle of the Louisiana State University Department of Agronomy supplied the soil descriptions.

Mr. Jack A. Bishop, Baker Printing Company, furnished advice relative to the arrangement of photographs and reproduced the manuscript.

Last, I wish to thank my parents for their encouragement and free room and board while working on the research area.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This two-year study (1963-1964) was completed in a loblolly-shortleaf pine-hardwood forest in central Louisiana. The primary objectives were to determine the yields and proximate chemical contents of fruit produced by 12 common understory, deer-browse plants. Relationships of tree basal area, tree canopy condition, and soil type with variations in yields and chemical contents of fruits were investigated. The 540-acre study area was sampled by using belt transects of three consecutive 4-milacre sampling units which were located on a grid pattern. The area sampled totaled 4.32 acres.

All fruits produced by the study plants located on the sampling units were collected as separate samples by species and unit. Oven-dry weights were used in the analyses of all data. Percentages of crude protein, phosphorus, potassium, and calcium were determined for each sample. A complete chemical analysis was made on a composite sample from each species. The phenological study of flower and fruit development was made by visiting the area bi-monthly, at which time pictures of flowers and/or fruits were taken.

The fruit crop of 1964 was almost double that produced in 1963. Parsley hawthorn, hawthorn, and arrowwood had greater yields in 1963; while French mulberry, flowering dogwood, yaupon, and tree huckleberry had larger crops in 1964. Mexican plum and muscadine produced a crop only in 1963, while blueberry fruit was collected only in 1964. The five most abundant fruit producers in 1963 were French mulberry,

Mexican plum, hawthorn, arrowwood, and flowering dogwood. French mulberry, flowering dogwood, tree huckleberry, arrowwood, and yaupon were the top five fruit-producing plants in 1964. Blackberry and rusty blackhaw had no fruit either year.

Generally, the yield of fruit from understory plants decreased with an increase in the basal area of the associated tree stand. Above-average yields were not obtained in 1963 where the tree basal area exceeded 50 square feet or in 1964 when it exceeded 60. The decrease in yields as basal area increased was smaller and less rapid in 1964, which had a near-normal rainfall.

The highest fruit yields were produced by plants growing on sites where the tree canopy was absent. Fruit production of plants growing below tree canopies was affected least by an overstory, next by a mid-story, and most by a multistory condition. Most of the fruit production occurred when the canopy was absent or present as an overstory.

Plants located on Beauregard (3-5 per cent slope) and local alluvial soils produced the largest fruit crops per acre. The least variation in yields between years occurred on the Beauregard (3-5 per cent slope) soil and the greatest was on the Sawyer (3-5 per cent slope) soil. Plants on two soil types, Beauregard (3-5 per cent slope) and alluvial, produced above-average crops both years.

Proximate chemical analyses of the various fruits showed that the following species had the highest content of the chemical constituents listed: parsley hawthorn - crude protein, phosphorus, and zinc; Mexican plum - potassium; flowering dogwood - calcium, fiber, and ash; youpon - magnesium; French mulberry - iron; arrowwood - fat.

A wide variation in chemical content existed between samples of the same species.

Flowers first appeared on Mexican plum in March and the last flowers were seen on French mulberry during July. The fall fruit crop began maturing in August on Mexican plum and muscadine and was not completed until the yaupon fruit matured in October. Mature fruit was seen in the field through December.

Accurate predictions of fruit yield could not be determined with the regression equations obtained from statistical analyses. Generally, the low multiple coefficients of determination indicated that factors other than those included in the analyses had major effects on fruit production.

INTRODUCTION

The number of deer in Louisiana has increased at a rapid rate during the last few decades in all areas that provide suitable habitat. This high population resulted largely from restocking programs and other management practices. But with the current intensive forest management practices and clearing of forested areas for other types of land use, there has been a reduction of suitable deer habitat. Large mast-producing hardwoods, which are an important source of deer and other wildlife food, are decreasing in numbers annually. The foods produced by sub-dominant woody vegetation that do not require space in the forest canopy have now become the object of new research studies. It is possible that fruit produced by the sub-dominant woody vegetation will become more important as a source of wildlife foods.

This investigation was a segment of a larger research program to determine the relationship of whitetailed deer (<u>Odocoileus</u> <u>virginianus</u>) to its habitat in a loblolly-shortleaf pine (<u>Pinus</u> <u>taeda</u> L.-<u>Pinus</u> <u>echinata</u> Mill.)-hardwood forest. It was made possible by a cooperative agreement between Louisiana State University and the Southern Forest Experiment Station, U. S. Forest Service. The objectives were to study fruit yield of selected deer-browse plants, their proximate chemical content, and the influence of tree density, tree canopy condition, and soil type on yield and chemical content. The plants selected were the most abundant fruit-producing understory browse plants normally found in an upland loblolly-shortleaf pine-hardwood forest in central Louisiana.

Many studies have been initiated to determine the fruit yield of the larger mast-producing hardwoods and its value to wildlife populations. The chemical content of mast has been the subject of several research projects. A review of literature indicated that very little effort has been directed toward estimating the fruit yield of the subdominant woody plants of the South. Deer habitat management is a complex problem which can be more effective as the habitat is better understood.

The purpose of this investigation was to determine the yield and chemical content of fruit produced by selected browse plants and evaluate the influence of timber stand conditions and soil types upon yield and chemical content. A study of the flowering and fruiting habits was also made. The investigation was initiated in December 1962 and completed in June 1965.

REVIEW OF LITERATURE

The published material reporting information on deer and their food and habitat requirements is voluminous. An investigation of the literature indicated that data pertaining to the fruit yield and chemical content of understory deer-browse plants are scarce. The literature review will consist of publications relevant to this research project. Only those articles dealing directly with yield, chemical content, growth, location, and factors affecting these phases of understory plant growth will be considered.

Browsing habits

Deer is important as a game species and has responded remarkably to management practices. Deer food and habitat requirements have been the subject of numerous investigations. Harlow (1959), in studying deer habitat in different forest types of Florida, found that deer nibble many different plants but only a relatively few species are browsed heavily. When preferred plants became scarce through over-utilization, deer browsed the less palatable plants.

Severinghaus and Cheatum (1961), after summarizing 11 studies made in forested areas of the South, concluded that essentially the same plant species were palatable to deer throughout the southern forest habitat. A bulletin edited by Halls and Ripley (1961) contains a list of the more important deer-browse plants of the South. General descriptions of the plants, their range, and value to deer are included, along with illustrations.

Dunkerson (1955) studied the browsing habit of a deer in a 90-acre enclosure for one year and the effects of browsing on preferred plants for four years in Ozark refuges. Green forbs were important throughout the year. Grasses, shrubs, fungi, fruits, seeds, and acorns were important seasonally. A number of plants were consistently unpalatable or palatable for only a short time during the growing season. No plants were found to be satisfactory indicators of winter range conditions. Shrubs which were palatable over a long period during the growing season served as best indicators of overpopulation on deer ranges. These shrubs may be the best deer range condition indicators for other southern hardwood areas as well as the Ozarks.

Goodrum and Reid (1962) summarized 14 years of deer browse studies and stressed the importance of preferred forage plants. The work was primarily carried out with known deer herds in a series of enclosures located in Louisiana, Mississippi, and Alabama. Deer fed on a wide variety of plants, but the staple foods consisted largely of woody browse and fruits of trees, shrubs, and vines. Deer browsed 67 species in Alabama as compared to 72 species in Louisiana and 96 in Mississippi. About 17 per cent of these plants were considered to be preferred food, 33 per cent were classed as medium-choice foods, and 50 per cent were low-choice foods. They found little increase in deer herds when about one-half of the preferred species was overbrowsed, although the animals appeared to be in good health. High-quality forage was not always adequate on normal ranges for the support of huntable deer herds in the Western Gulf region. It was indicated that late summer and winter could be the critical food periods for deer.

Goodrum and Reid stated that a variety of mast-bearing trees, shrubs, and vines was needed to maintain the health and vigor of the herds.

Data were collected in the Khopersk Forest Preserve in Russia by Protoklitova (1963) on yield and estimates of deer browsing on test areas and experimental feeding of deer in enclosures from December 1958 to March 1961. A list of plants on the test areas contained 236 species, but only 57 were utilized by the deer. The majority of plants in this study were new food types for deer. Forbs and grasses predominated in the spring and summer diets, but tree and brush vegetation was utilized almost exclusively during the winter.

Determination of the foods which Florida deer selected during the fall and winter months was obtained by the analysis of 485 stomach samples collected statewide from September to February 1952-1959 (Harlow 1961). The deer utilized a wide variety of plant species, but a comparatively few plants composed the bulk of the diet. Twenty-one species, out of 193 recorded, amounted to 83.7 per cent of the total sample volume. The ten preferred foods, according to the analyses, included oak (<u>Quercus</u> spp.)-acorns; Basidiomycetes-entire; trilisa (<u>Trilisa</u> <u>odoratissima</u>)-basal leaves; saw palmetto (<u>Serenoa</u> <u>repens</u> Small.)-berries; inkberry holly (<u>Ilex</u> <u>glabra</u> L.)-leaves, twigs, berries; virginia sweetspear (<u>Itea</u> <u>virginica</u> L.)-leaves and twigs; greenbrier (<u>Smilax</u> spp.)-leaves, twigs, berries; and buckwheat-tree (<u>Cliftonia</u> <u>monophylla</u> Britt.)-leaves and twigs. Oak acorns and palmetto berries constituted a major portion of the deer diet when present on the deer range. Basidiomycetes were important as deer food in the flatwoods and pine-oak upland habitat. Deer in the freshwater

Everglades utilized forbes, mainly hydrophytic, most frequently with woody plants ranked as second choice.

Pearson (1943) studied the December food habits of deer in Alabama from 1936 to 1941 by examining 195 stomach samples. Oak acorns accounted for 48.85 per cent of the food by volume. Several oak species were included, with southern red oak (_Quercus rubra_ L.) being most common, but use was apparently based primarily on availability. Other foods comprising greater than 2 per cent of volume were: greenbrier - leaves, fruits, and stems; sumac (_Rhus_ spp.)-fruit, twigs, and leaves; dogwood (_Cornus_ spp.)-leaves and fruit; and cross-vine (_Bignonia capreolata_ L.).

A study of deer foods of Missouri with some forest management implications was based upon the analyses of 578 stomach samples collected over a five-year period (Korschgen 1962). Only 20 individual food items, out of the 272 identified, comprised at least one per cent of the total volume. Oak mast, cultivated grains, and fruits were the staple deer foods in Missouri. Use of oak mast was related to its availability, and during years of crop failures other foods were utilized in higher proportions. Coralberry (_Symphoricarpos orbiculatus_ Moench), dwarf sumac (_Rhus copallinum_ L.), smooth sumac (_Rhus glabra_ L.), eastern redcedar (_Juniperus virginiana_ L.), soybeans (_Glycine soja_ L.), wild grapes (_Vitis_ spp.), New Jersey tea (_Ceanothus americanus_ L.), asters (_Aster_ spp.), and wild lettuce (_Lactuca_ spp.) can be used as indicators in determining trends in range conditions. Korschgen concluded that starvation foods of the western Ozark region were eastern redcedar and oak leaves and that mast failure or severe drought might seriously affect deer range through reduction of nutritious foods. Stomach analyses showing significant increases in grazed or browsed foods should alert the game manager to necessary herd reduction because of food shortages or overpopulation.

An agricultural evaluation of plant foods and water for white-tailed deer and wild turkey was made by Davison and Graetz (1957). They listed 161 choice and 230 less palatable deer foods and 67 choice and 81 less desirable turkey foods. They found that deer would eat almost every plant that turkey utilized. The authors suggested that grasses and herbs were utilized more and were more important as food than woody species, and the usual methods of deer-food studies exaggerated the woody browse and failed to evaluate herbaceous foods adequately. They concluded that foods grown by cultivation, fertilization, liming, etc. would increase the health, body weight, antlers, and reproduction rate of deer; but increased food was no substitute for herd management to prevent over-grazing and over-browsing.

Fruit production and utilization

Lay (1961) reported partial success in developing statistical equations for estimating fruit production of some understory hardwoods. These plants do not require space in the overhead canopy; therefore, they are being reappraised as deer food on areas managed for commercial timber production. He found that fruit production on understory hardwoods was usually greater than that on oak trees, when compared on the basis of basal area. Lay stated that much more research was needed to determine the true value of the fruit-producing understory hardwoods in pine-hardwood forests. Fruits, in some cases, might be more important than the foliage produced by plants.

Native and exotic deciduous trees and shrubs, which produced fruits utilized by wildlife on the Kellogg Forest near Battle Creek, Michigan, were studied over an eight-year period to determine the degree of variability of fruiting and its possible significance to wildlife (Gysel and Lemmien 1964). During five of the eight years, at least moderate quantities of acorns were available to wildlife, and most of the other plant species produced some fruit each year. There was a definite relationship between site quality and fruit production on the area. A variety of fruits was available to the animals each year. The fruit yield was presented in grams per square foot of crown surface.

Acorns, recognized as an important food for wildlife, were but one of many important fruits produced by trees, shrubs, and vines eaten by the wildlife of eastern Texas (Lay 1962). Deer utilized the fruits of almost every available plant species, including hickory (*Carya* spp.). Recent studies indicated that fruits produced by some species were important enough to justify the plants' space in the managed forest, but increased use of fire and herbicides to control the smaller hardwoods has reduced this source of food. Dogwoods, on which no complete crop failure was observed, produced 3.3 pounds of fruit per tree or 38 pounds per acre. The fruit was utilized by deer as long as the flesh was sound. Fringetree production averaged slightly over one pound of fruit per tree, and deer fed on this fruit from June to November. French mulberry, which averaged about 1/2 pound of fruit per plant, may produce as much as 50 pounds of fruit per acre. Seeds of French mulberry, which is not digestible by deer, have been found in deer pellets from June to March. Blueberry hawthorn (Crataegus brachyacantha Sarg. and Engelm.) produced 2.4 pounds of fruit per tree and did not have a crop failure for at least three years. Flatwoods plum (Prunus umbellata Ell.), sweetleaf (Symplocos tinctoria L'Her.), and viburnum (Viburnum spp.) also produced fruit on a reasonably consistent basis.

Murphy and Ehrenreich (1965) reported an investigation of the noncommercial understory plants which produce fruits utilized by wildlife. The two primary objectives were to determine the frequency of occurrence and per cent of plants with fruit. Relationships between forest types, crown cover of overstory, and physiographic factors with abundance and fruiting of the plants were indicated. The abundance varied by forest type with the greatest variety and density occurring in the bottomland type. None of the fruiting species had a high percentage of plants bearing fruit. Analysis of data indicated that abundance and fruiting were influenced by crown cover of overstory trees, aspect, and position on slope. No attempt was made to measure the amount of fruit produced by the plants.

The results of a four-year study, 1935-1938, in the Monongahela National Forest of West Virginia, were published by Park (1942). He indicated that the variety of wildlife food plants rather than the quantity of one, or a few species, was the primary factor responsible for the best year-round wildlife habitat. Generally, greater species variety will assure the most stable environment. He found that the fruit ripening date for each species included in the study was very consistent, with 15 days being the maximum variation for any one species. Annual variation in availability or lasting quality was considerably less than variations in yield. Average fruit yields for most species usually have little meaning, since the variation in yield of a single species is so great. Park indicated that the percentage of plants bearing fruit was 70 or higher for deciduous holly (Ilex decidua Walt.) and three other species; oaks, large enough to produce fruit, had the lowest average of 21 per cent. All plants observed bore fruit in 1935, 66 per cent had fruit in 1936 and 1937, and 71 per cent fruited in 1938. Only nine species, or 33 per cent, produced a yearly crop. Hawthorn (Crataegus spp.) was one of the six most prolific fruit producers.

Dalke (1953) reported on a study of the yield of seeds and mast in a second-growth hardwood forest of south-central Missouri which was related to wild turkey management. The timber in the area varied from dense sprout growth to scattered stands of mixed oak-hickory. In 1938, 22.8 per cent of the milacre plots had no fruit yield, and the following year, 44.9 per cent had no yield. The yield of fruit in 1938 was 90 per cent greater than the 1939 yield. Nineteen plant species were included in the study.

The results of a five-year study on the value of hawthorns to wildlife in Pennsylvania was reported by Hoover (1961). Data were collected from 632 hawthorn stands over a 75-mile-wide transect which extended across central Pennsylvania from York and Adams counties to McKean and Tioga counties. Hawthorns of this area grew best on a moist to wet site but would tolerate a wide range of habitat sites.

They were not resistant to heavy browsing under shaded conditions. Stands composed of two or more species of hawthorns were usually more consistent in the quantity of fruit produced from year to year.

Hoover indicated that weather conditions, during the time hawthorns flowered, and rust infestations in the southern part of the state appeared to be the primary causes of fruit yield fluctuations. It was not common for plants to produce excellent crops for two successive years, and variations in fruit yield did not follow a consistent pattern during the study. Actual estimates of fruit yields were not made.

Phillips (1959), in a review of the hawthorns of this country, indicated that the fruits are an important food of grouse and other large birds, deer, rabbit (Sylvilagus spp.), raccoon (Procyon lotor), squirrel (Sciurus spp.), and fox (Vulpes fulva and Urocyon cinereoargenteus). Because of its dense branching habit and spines, hawthorns make excellent cover and nesting sites for birds.

Parsons (1955) wrote that blackberry (Rubus spp.), like everything else, definitely has its place in nature. The thick, rapid growth serves to prevent erosion of cleared areas and provides shade and protection for tree seedlings that will later take over the site. It serves as a shelter and produces food for countless song birds, game birds, and many other animals. Ruffed grouse (Bonasa umbellus), turkey (Melcagris gallopave), ring-necked pheasant (Phasianus colchicus), robin (Turdus migratorius), and other birds have been observed eating the fruit. Deer, black bear (Euarctos americanus), rabbits, chipmunks (Tamias striatus), squirrels, and even mice (Reithrodontomys spp. and *Peromyscus* spp.) have been seen devouring the ripe berries.

Vimmerstedt (1957) found that flowering dogwood (*Cornus florida* L.) produced a good seed crop every two years. Flowering dogwood, a very tolerant plant, carried on maximum photosynthesis at one-third of full sunlight. He stated that seeds produced on isolated trees are frequently hollow, which would reduce their wildlife value. Flowering dogwood is very intolerant to drought and it is easily injured by fire.

An investigation of the fruit utilized by deer in southern forests was reported by Lay (1965). During a seven-year period (1956-1963) in east Texas, 2,295 pellet groups plus 49 stomachs obtained in 1963 were inspected for woody plant fruits or fruit and seed remains that could be identified. The time of fruit maturity or availability was usually closely related to peaks of utilization. Some fruits, those that remained on the plants after maturity and those which resisted deterioration after falling to the ground, were eaten over a longer period of time. French mulberry (*Callicarpa americana* L.), white fringetree (*Chionanthus virginica* L.), yaupon (*Ilex vomitoria* Ait.), hawthorn, and oak fruit were found over extended periods of time. Oaks, yaupon, French mulberry, black tupelo (*Nyssa sylvatica* Marsh.), and hawthorn fruits were found more frequently. Some fruit remains were found for every month, but highest utilization occurred when most available. Ranges, with a large variety of hardwoods of fruit-producing size, contributed more to deer diet than areas which offered little except browse, as deer utilized the fruit when available. Fruit remains of 31 species or genera were identified in the analyses.

Deer-habitat relationship

Deer seem to achieve maximum densities in areas of disturbed vegetation which produce palatable shrubs and tree reproduction as secondary stages in plant succession (Leopold 1950). Logging, fire, and grazing were the three principal influences which, in the past, have created or improved most of our present deer ranges. These influences can destroy ranges when in excess, and it should be obvious that optimum deer production can not be attained by permitting either overstocking or understocking of the range. Regulation of deer numbers, so that range carrying capacity is not exceeded, is one of the basic requirements of sound deer management.

Halls and Crawford (1960) reported that deer herds increased rapidly in the Arkansas Ozarks where the habitat was favorable and soon exceeded the carrying capacity of the range. Continued overbrowsing seriously reduced available forage which resulted in a decline of the herd. Preferred browse plants were affected most, and in areas of recovery, the range contained a higher percentage of nonpreferred plants. The development and structure of the forest also affected the habitat potential. In the reproduction phase, food was plentiful; but as the stand increased in size and the canopy closed, most of the understory disappeared. Forage became more plentiful after a timber harvest. Abused habitat seemed to recover about as rapidly under light to moderate use as under complete protection.

The relationship of deer to longleaf pine (Pinus palustris Mill.) habitat was investigated by Goodrum and Reid (1958). They estimated that about 78 woody plant species were available to deer in a given locality. About 50 per cent of these plants were classed as starvation foods. When about one-half of the preferred species were overbrowsed, then overstocking was imminent and herd reduction was in order. Browse in the South was most nutritious in the spring when succulent. Sometimes the nutritive value drops as much as 50 per cent by winter. On natural range, this was offset by the highly nutritious acorns and other mast. They reported that prescribed burning helped deer by stimulating sprout growth, increasing forbs, and by raising the nutritive level of browse. It was estimated that longleaf pine habitat would support about one deer to 26 acres and still maintain fawn production.

Leopold (1936B) compiled a list of German browse species in descending order of palatability according to his own observations. In deer forests, the preferred browse plants no longer existed except on areas protected by fence; the staples or second-class plants were sometimes scarce or absent, and the emergency foods showed some browsing, even during the summer. This indicated that the palatable species no longer existed on certain areas because of the deer and the system of silviculture which prevailed. Yew (Taxus spp.), a very palatable species, was virtually extinct as a wild plant, although records showed that it had been very common. Many other desirable browse plants also disappeared, as the floral list in deer forest has been reduced by at least 66 per cent. Artificial feeding became a common practice and kept deer alive which would normally have starved. This practice, in turn, enlarged the discrepancy between game density and natural forage. Intensified game damage to forest vegetation and agricultural crops resulted in increased protection costs. A degeneration of deer occurred because of the unbalanced diets.

Prevention of browsing and peeling by game, particularly red deer (Crevus elaphus) was one of the essential measures given by Winkler (1935) to increase the productivity of the German forests, especially spruce (Picea spp.) forests. Game density must be reduced to within the carrying capacity of the range in order to accomplish this. Additional food for wildlife can be provided by developing mixed forest stands, introducing palatable shrubs and herbaceous plants, maintaining mast-bearing trees, and developing game gardens and meadows. Areas of tree reproduction should be fenced, and artificial, winter feeding was suggested.

Holloway (1950) discussed the problems arising out of the acclimatization of deer in the indigenous forests of New Zealand by using examples drawn from forests of Western Southland. The complexity of the problems and the changes which occur in the forest composition were stressed. Effects of deer browsing on six forest types were presented and the future of these types was forecast. A list of the major food plants in order of palatability was presented, and the use of this list in studying deer-habitat relationships were indicated.

Leopold (1950A) stated that when stripped of all qualifying detail, the problem of managing deer may be reduced to the following two generalizations. One is to manipulate plant succession to influence future range conditions. The second is to balance the deer herd to current range capacities at all times. This latter point is being widely undertaken by adjustments in local hunting laws, aimed at herd regulation. Comparatively little thought has gone into the more basic point of regulating plant succession for deer. The forest is continually being slashed and burned while the range is being overgrazed; and both processes have produced some of our best deer ranges in the past, but have destroyed others. Creation of deer ranges in the future will have to be carried out in a more deliberate manner as part of wildland management. This management will have to be done with due regard for other land values and uses. Merely protection or moderate use of the forest range will not suffice. Purposeful maintenance of young nutritious brush on key areas will become necessary for proper deer management.

Forest management - wildlife relationship

The correlation of silvicultural systems and wildlife management was the subject of an article by Scott and Fowle (1952). They suggested the need of more cooperative studies on forest and animal relations by stating several general points. The successful practice of both wildlife management and forestry depend upon a thorough understanding of the interrelationships of the living things in a forest. Then manipulation of the whole community can be successfully carried out to produce the environment that favor the desired forest and wildlife species. Intensive management programs produce the best results, but programs on an extensive basis were better than none. General recognition of habitat as the key to wildlife production should lead to closer integration of wildlife management and silviculture on an intensive scale. In relation to intensity of management, the importance of continuity of management was recognized, because single treatments followed by a period of neglect were seldom effective. They stated that the public demand for better use of available natural resources will require multiple-purpose management programs.

Small openings created by timber removal in the Missouri Ozark forests usually resulted in a substantial increase in herbaceous vegetation unless the openings were too small or occurred where a dense stand of tree reproduction existed (Martin, et al. 1955). Forbes were most abundant on all plots, grasses were next, then browse plants. There was always some increase in forage on areas released by timber removal, and the resulting forage was considered to be more valuable to deer than cattle. The forage was not only more suitable to deer, but deer were better adapted than cattle to utilizing the widely scattered spots of increased forage.

Schuster and Halls (1963) reported the results of a study which indicated that the abundance or scarcity of forage was chiefly determined by timber stand structure. Some relations between understory and overstory vegetation in typical shortleaf-loblolly pine-hardwood forest stands cut by various silvicultural systems are obvious. The midstory crown cover strongly influenced forage growth on all plots, because the forage yields were reduced as the crown cover became more dense. When the midstory was overtopped by dominant trees, forage yields were further reduced, but to a lesser degree, and very little light penetrated to the ground. Forage yields were more closely correlated with crown cover than with soil and physiographic factors. Browse plants palatable to deer were more tolerant to shade than unpalatable plants. In cleared areas, the ratio of desirable to undesirable species was 50:50, while under a tree canopy the ratio was 66:34. Valuable browse plants were generally more numerous on plots having good timber stocking.

Lay and Taylor (1943) investigated the effect of clear cutting timber on some of the plant and animal associations in eastern Texas. Deer were benefited by the timber removal in direct proportion to the amount of woody and herbaceous vegetation produced as a result of the harvest. Excellent deer food and cover were found from 2 to 10 years after timber removal and remained adequate for some 25 years or until the young timber approached maturity. Under present forest management practices, the second growth trees never dominated the understory enough to impair the deer-carrying capacity. They stated that virgin timber was not an optimum habitat for deer and many other species of wildlife, because the closed canopy formed by mature trees shaded out most of the grasses, herbs, and shrubs on which the animals depend for food and shelter.

The importance of understory vegetation for deer was emphasized by Blair (1960). He reported that different intensities of thinning on a central Louisiana loblolly pine plantation had a direct effect on the production of understory vegetation. This means that the type of management practiced in a forest would have a direct relation on the amount of food available to deer. On a given site, the more open the forest stand, the more dense will be the understory vegetation. Blair found that the palatable browse available during the winter was approximately 63 per cent of that available during the summer.

Patton (1963) investigated the response of deer food production to different forest-cutting intensities on the Jefferson National Forest of Virginia. The effect of time on the response was also studied. Current annual growth of browse plants growing on sample plots, located in 11 cut and 4 uncut areas, was clipped and weighed. Results indicated that the amount of browse produced on the cut areas was directly related to the per cent of stand removed and number of years after cutting.

Lay (1955) studied the effects of prescribed burning on forage and mast production in a southern pine forest. He reported that prescribed burning in southeast Texas reduced browse for two years and increased herbaceous forage for at least three years. There was little overall change in total forage production. Changes in floral composition resulting from burning were more pronounced than changes in quantity. Plants which increased after burning were grasses, sedges, herbs, French mulberry, viburnum, smilax (Smilax spp.), blackberry (Rubus spp.), sweetgum (Liquidamber styraciflua L.), and sweetleaf. The species which were reduced in number were American holly (Ilex opaca Ait.), blackgum (Nyssa sylvatica Marsh.), yellow jessamine (Gelsemium sempervirens Ait.), dogwood (Cornus spp.), wax myrtle (Myrica spp.), yaupon, and tree huckleberry (Vaccinium arboreum Marsh.). Burning reduced the number of understory plants of fruiting size by 62 to 72 per cent and the number of plants with fruit, 68 to 72 per cent. Fruit production of dogwood increased 83 per cent. Benefits gained by wildlife through prescribed burning increase as the understory succession progresses away from the desired habitat conditions.

The effects of releasing browse, grasses, and forbs in a post oak-blackjack oak (*Quercus stellata* Wang.) - (*Quercus marilandica* Muenchh.) forest type having dense tree reproduction were studied quantitatively by Baskett, *et al*. (1957). Cull trees were girdled according to U. S. Forest Service procedures in order to initiate the release. A severe drought affected the results, but tree reproduction and all types of forage were more abundant on the released areas after five years. The treated area had 30 per cent more browse, 72 per cent more grasses and sedges, and 35 per cent more forbs than the untreated areas when the study terminated. They stated that even in this timber type with dense tree reproduction, standard silvicultural procedures favor production of forage.

Gysel (1957) reported that when pines were released by eliminating overstory oak, the environmental changes produced a more favorable habitat for forest game. The additional growth of understory plants such as grasses, fruit-producing shrubs, and sprouts provided additional food and cover. Cutting and girdling proved more productive in producing such plants than the use of herbicides, but this situation was alleviated somewhat by leaving individual trees or strips unsprayed.

Mikola (1958) stated that Finland's climate has warmed in the past 100 years, and the northern timber line has advanced to the benefit of game. The original forest clearing and burning promoted the establishment of mixed deciduous vegetation which produced a favorable habitat for wildlife. Forestry practices of recent years reduced or eliminated the deciduous trees in medium-aged or old forest but increased deciduous growth when new stands were established by broadcast burning. Any forestry practice that promoted growth of deciduous vegetation also favored wildlife.

A discussion of German deer and forestry practices through nine centuries was made by Leopold (1936A). As there were no livestock to disturb the issues, the following conclusions were drawn concerning forest-game relationships: (1) better silviculture results were possible only with a radical reform in game management, and (2) better game management results were possible only with a radical change in silviculture. Early hunters and foresters, who were actually game managers and enforcement agents, recognized the value of mast and browse, both shrubs and tree reproduction, in maintaining high deer densities. During peaks in deer density, damage to forest was recognized and more liberal hunting regulations and artificial feeding were developed in order to reduce the deer damage. During periods of low deer densities protection, predator control, and management programs were used to increase the herds. Sometimes forestry practices accidentally produced ideal deer habitats. The protection, management, and hunting of wildlife was usually controlled by the landowner. German history, in most instances, presents a clear case of mutual interference between forestry and game-management practices.

Nutritional requirements

Some nutritional problems of deer in the southern pine forests were discussed by Lay (1956). He found that winter was the most critical period for deer since the quantity and quality of food was lowest at that time. The winter browse contained about six per cent protein and 0.16 per cent phosphoric acid, which is below the minimum adequate levels of about seven per cent protein and 0.35 per cent phosphoric acid. The evergreen species contained higher percentages than deciduous species. It was indicated that the carrying capacity can be increased by the planting of winter greens, fertilization, release of common desirable species, prescribed burning, timber removal, increasing acorn supply, removal of hogs and cattle, or with planting of palatable evergreens. Deer herd control was necessary, regardless of the carrying capacity.

French, et al. (1955) investigated the nutritional requirements of whitetailed deer for normal growth and antler development. Rations on which various penned male fawns were reared to maturity were full and half. These rations were deficient in calcium, phosphorus, protein, sulphur, or sulphur-amino acids. Rations for normal growth contained 13 to 16 per cent protein, 0.09+ per cent calcium, and over 0.25 per cent phosphorus. Body growth always took precedence over antler growth. Deer kept on diets low in carbohydrates, calcium, phosphorus, and protein weighed only half as much as the controls and developed thin spikes.

McEwen, et al. (1957) studied the nutrient requirements of whitetailed deer by feeding captive deer controlled diets. Twenty to 30 deer were control-fed various rations which had different nutritional levels. The optimum mineral level of the food was about 0.65 per cent calcium, 0.55 per cent phosphorus, and 17 per cent protein. The minimum level for survival was 0.25 to 0.30 per cent calcium and phosphorus and 4 to 5 per cent protein. The minimum level was tolerated during winter with less stress if deer entered winter in good condition.

Swank (1956) stated that since food was the dominant factor in the control of deer population levels and that nutritive values were of particular value, testing of browse species for their nutritive contents was a major phase of his study. He found that plants contained the highest per cent of moisture, phosphorus, and protein during the growing season. The results of the study and work by other investigators indicate that throughout the West, deer densities were definitely controlled by the nutritive levels of the food available in their range.

Bubeník and Lochman (1956) published an account of methods used by the Institute for Forestry and Wildlife Management in Czechoslovakia to solve the fundamental problems of nutritional physiology of antlered deer. Consumption rates and digestibility of foods, daily feeding rhythm, and influence of different foods upon the course of feeding were investigated. Some of the results do not conform to the experiences with domesticated ruminants. Other results were correlated to the damages caused by the browsing habits of deer.

Chemical content studies

Caillouet (1960) analyzed fruits or seeds of 74 plant species found in Louisiana for nutritive values and found considerable variation in nutrient contents within family and species. Seeds or fruits of certain plants exhibited high percentages of a particular nutrient. The fleshy portion and seeds of fruits of some species were found to contain very different proportions of nutrients. He discussed seeds and fruits as to their relative importance as foods to wildlife (quail).

Spinner and Bishop (1950) collected some fruits and seeds of value as wildlife foods in Connecticut from 1941-1947 and analyzed them. They failed in their attempts to correlate utilization with nutritive value as measured by chemical composition. Their results were compared with other studies and a similarity of chemical composition was evident over the entire range of the plant. There was no indication of a difference in chemical composition as the season progressed.

The chemical composition of hardwood tree fruits in Pennsylvania was studied by Wainio and Forbes (1941). Fruits and berries were usually rich in nitrogen-free extract and less rich in protein and ether extract, and for that reason, most of the fruits and berries were classed as energy foods. The nuts, because of their high protein and fat content, were of greater value in building up reserve energy. It was concluded that due to the highly complex food requirements of animals, no one food can serve as a complete diet.

Hundley (1959), in studying the available nutrients of selected deer browse, revealed that soil types may have little effect on the nutritive value of a plant species. The nutritive contents of five preferred deer-browse plants, growing on four study areas near Blacksburg, Virginia, were determined by analyzing current-year twigs over a one-year period. Some of the plants were high in moisture content, ether extract, ash, and nitrogen-free extract, but low in protein and crude fiber. Others were high in protein and crude fiber and low in the other elements. He found that soil types have little effect on the nutritive contents of a plant species.

Hundley stated that present knowledge is insufficient to allow the use of proximate analysis as a basis for rating different plant species with regard to which provides the most nutritious browse for deer, but such information might be helpful in evaluating a habitat. Although it is possible to determine which species does best on a given soil for a specific nutritive quality, it was not possible to detect clear trends and consistencies in nutritive contents of species collected on the study areas. Individuals within a species had different nutritive contents when growing on the same soil. Different soils had their greatest effect on the nutritive contents of plants during April and August. Moisture content was most affected and protein content least affected by soil types.

A report of the chemical composition of browse growing on two wildlife management areas of North Carolina was made by Smith, et al. (1956). The material was analyzed for calcium, phosphorus, manganese and cobalt, protein, crude fat, crude fiber, and nitrogen-free extract. The Coastal Plain area, which supported a low density of unthrifty deer, was deficient in protein, phosphorus, cobalt, and crude fiber and high in crude fat and nitrogen-free extract. The percentages did not remain constant throughout the year. It was concluded that inadequate protein, phosphorus, and cobalt were, in part, the cause of the unthrifty condition in deer. Herbage in the mountain area varied in chemical contents also but was probably adequate for supporting deer.

A study of the nutritive value of twigs palatable to deer was made in Pennsylvania by Hellmers (1940). The investigation was made on an area which supported an estimated density of one deer per 18 acres. The samples, collected from November 1937 to April 1938, were shoots of the previous growing season. He found that a translocation of available food occurred in the leaves and stem tips of the plants. The results indicated that a reduction in nutritive value occurred during the winter months.

Browne (1938) reported that several factors influenced the mineral composition of crops. One of these factors was the soil. Climatic factors such as temperature, humidity, rainfall, light, and altitude influenced the composition by their affect on respiration, assimilation, photosynthesis, metabolism, and other physiological processes of plants. Browne indicated that as a general rule, increased water supply increased the absorption of mineral matter from soil.

Dewitt and Derby (1955) studied four common browse plants to determine the effects of low- and high-intensity fires upon the chemical composition of plants. The results of the study indicated that neither type of fire affected the total solids, ash, ether-extracts, crude fiber, and nitrogen-free extracts of red maple (_Acer rubrum_ L.), flowering dogwood, white oak (_Quercus alba_ L.), and roundleaf greenbrier (_Smilax rotundifolia_ L.). The protein contents of all plants, except white oak, were significantly higher the year following low-intensity burns, but no effect could be determined the second year. The high-intensity fires produced significant increases in protein contents of all species for at least two years following the burn.

Wilde (1946) investigated the soil-fertility standards of selected food plants and found that plants on very poor burned-over podzols and coarse siliceous sands usually do not produce fruit, even during good crop-producing years. The occurrence of a species on a certain site is not necessarily proof of its ability to produce an abundant food crop on that site. Many game food plants in Wisconsin apparently have restricted bearing ability due to low soil fertility as well as light deficiencies and climatic extremes. Even if a food crop is produced on soils deficient in some essential elements, the fruit may not have an adequate nutrient value for game. Wilde reported that Leopold also observed the production of more valuable game foods on the better soils.

The review of literature presented here indicates that the determination of the best management practices for deer habitat presents a complex problem. Most timber management practices in upland forests of the South favor pine. Forestry practices that favor pine tend to make sub-dominant hardwoods the primary source of food; therefore, it is important to know the value of these plants to deer. In order to completely understand this value, the potential production of food by the plants must be known. This review indicates that information on the fruit yield of these understory plants is relatively scarce.

THE RESEARCH AREA

The study was carried out on a 540-acre forested research area established by the U. S. Forest Service and the Louisiana Wild Life and Fisheries Commission and located about six miles south of Winnfield, Winn Parish, Louisiana on the Winn District, Kisatchie National Forest. The experimental area is located on the following parts of T. 10 N., R. 2 W.: section 10, E$\frac{1}{2}$ of SE$\frac{1}{4}$; section 11, W$\frac{1}{2}$ of the SW$\frac{1}{4}$; section 14, NW$\frac{1}{4}$ of the NW$\frac{1}{4}$; section 15, N$\frac{1}{2}$; and section 16, the NE$\frac{1}{4}$ and the E$\frac{1}{2}$ of the NW$\frac{1}{4}$. Figure 1 illustrates the approximate location of the study area within the parish and state. Six experimental closure units were formed in 1960 by the erection of a nine-foot deer-proof fence. Each of three 160-acre enclosures has an adjacent 20-acre exclosure. Deer herds representing one deer per 20, 40, and 80 acres were maintained with unbred young doe deer immediately after completion of the fence. All the study plots were located within these closures on a grid pattern as shown in Figure 1.

The topography of the area is typical of the upland loblolly-shortleaf pine-hardwood forested region of central Louisiana. The hills in this area had slopes that varied from one to twenty per cent, and there were poorly drained flats and stream bottoms. Large streams were avoided due to the difficulty of maintaining fences across them. According to the soil type map, prepared by the U. S. Soil Conservation Service, the area has at least 13 different soil types. This wide range of physical features made the research area typical of most of

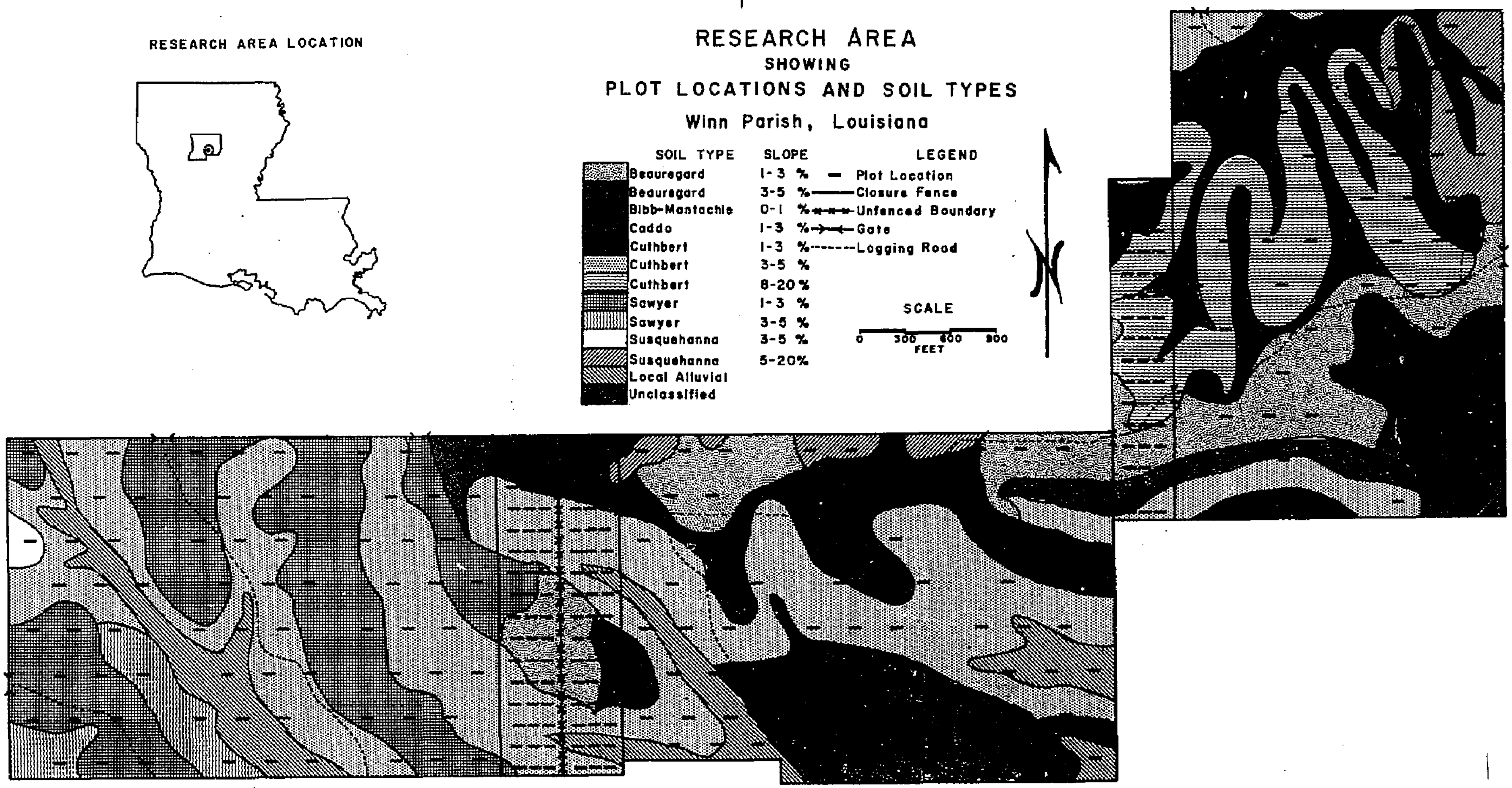
Figure 1. Map of research area.

Closures are numbered, west to east, or left to right, 1, 2, 3, 4, 5, and 6.

Numbers 1, 4, and 6 are enclosures.

Numbers 2, 3, and 5 are exclosures.

The unclassified soil was later identified as belonging to the Bowie series.


RESEARCH AREA LOCATION
RESEARCH AREA
SHOWING
PLOT LOCATIONS AND SOIL TYPES
Winn Parish, Louisiana
SOIL TYPE
SLOPE
LEGEND
Beauregard 1-3 %
Beauregard 3-5 %
Bibb-Mantachie 0-1 %
Caddo 1-3 %
Cuthbert 1-3 %
Cuthbert 3-5 %
Cuthbert 8-20 %
Sawyer 1-3 %
Sawyer 3-5 %
Susquehanna 3-5 %
Susquehanna 5-20%
Local Alluvial
Unclassified
Plot Location
Closure Fence
Unfenced Boundary
Gate
Logging Road
SCALE
0 300 600 900
FEET
N

the upland regions of central and northern Louisiana.

Areas suitable for marginal cultivation were cleared and farmed at one time, and the remaining land was left in a forested condition, except the merchantable timber which was removed. Cleared areas reverted to an all-aged mixed pine-hardwood forest after they were abandoned. Apparently the forest was allowed to reestablish itself naturally, as confirmable evidence of any type of forest management was wanting until recent years.

An intermediate cutting for pine and hardwood was completed in 1957 to bring the area into an experimental multiple-use program to study problems of producing combined commercial tree crops and huntable wildlife populations. The merchantable pine was reduced to a residual stand of about 5,000 board feet per acre. Other forest management practices applied to the timber stand included a girdling operation in 1958 to kill the nonmerchantable hardwoods which were suppressing established pine reproduction, and a railroad tie-cut of hardwoods was completed in 1960 to further reduce hardwood competition.

The area had not been burned for at least 10 years prior to 1960, and forage utilization by domestic stock and deer was considered light. After the fence was completed, all animals were driven from the closures, and the enclosures were stocked with known numbers of young unbred doe deer. Prior to the establishment of the study, this area was open to public hunting. Small game hunting is not allowed now due to the possibility of disturbing the deer.

Although no attempt was made to census the small animal population during the study, visible sightings and signs indicated that a relatively dense population of squirrels, rabbits, raccoons, and opossums existed on the area. Several coveys of quail were flushed regularly while working on the area, and small non-game birds were numerous.

OBJECTIVES OF STUDY

This research program was designed to measure the fruit production of selected understory woody plants found in the loblolly-shortleaf pine-hardwood forest of central Louisiana. The plants listed in Table 1 were selected on the bases of their importance as browse to deer, their productivity, and their frequency of occurrence on the study area. This study was a segment of a research project in which the interrelationship of deer to their habitat was investigated in a forest managed primarily for timber production.

Data were gathered on the selected fruit-producing deer-browse plants found on the study area. It was believed that these species were fairly representative of those found in the loblolly-shortleaf pine-hardwood forest of the Gulf Coastal Plain. The results should provide information that will be helpful in managing deer herds throughout this forest type.

The specific objectives of this research study were as follows:

1. to determine fruit yield by fresh and dry weights.
2. to study the effect of forest canopy, tree basal area, and soil type on fruit production.
3. to chemically analyze fruit produced by the selected browse plants.
4. to make a phenological investigation of flowering and fruiting habits.

Table 1. Deer-browse plants selected for this study

Common name	Scientific name
French mulberry	*Callicarpa americana* L.
Dogwood	*Cornus florida* L.
Parsley hawthorn	*Crataegus marshallii* Eggelston
Hawthorn	*Crataegus* spp.
Yaupon	*Ilex vomitoria* Ait.
Mexican plum	*Prunus mexicana* S. Wats.
Blackberry	*Rubus* spp.
Blueberry	*Vaccinium* spp.
Tree huckleberry	*Vaccinium arboreum* Marsh.
Rusty blackhaw	*Viburnum rufidulum* Raf.
Arrowwood	*Viburnum dentatum* L.
Muscadine	*Vitis rotundifolia* Michx.

METHODS AND PROCEDURES

Plot layout

In order to prevent possible conflicts and disturbances of plots previously established by the U. S. Forest Service, the belt transects used in this study were located by the same grid pattern used to locate the milacre forage plots. The east-west grid lines in the enclosures were 273 feet apart and the north-south lines were 282 feet apart. Exclosure east-west grid lines were run every 134 feet and the north-south lines were 104 feet apart. Every fourth intersect marked the location of a temporary forage clipping plot. The remainder of the intersects were used in locating the permanent milacre forage plots, and these were used as reference points in locating the transects (see Figure 2). There were 360 such plots on the study area, 72 in each enclosure and 48 in each exclosure.

The belt transects were located on the east-west grid lines in the direction of travel. Forage plot boundaries were used as guides for the two parallel lines extended on the same grid bearing 6.6 feet apart to establish the 10-foot buffer zone and 79.2-foot long plot. Each 12-milacre belt transect plot was divided into three consecutive four-milacre units to facilitate the inventory and fruit collection. The corners of each unit were marked with pins constructed of heavy gauge telephone wire. The total area sampled was 4.32 acres, .86 acre per enclosure and .58 acre per exclosure.

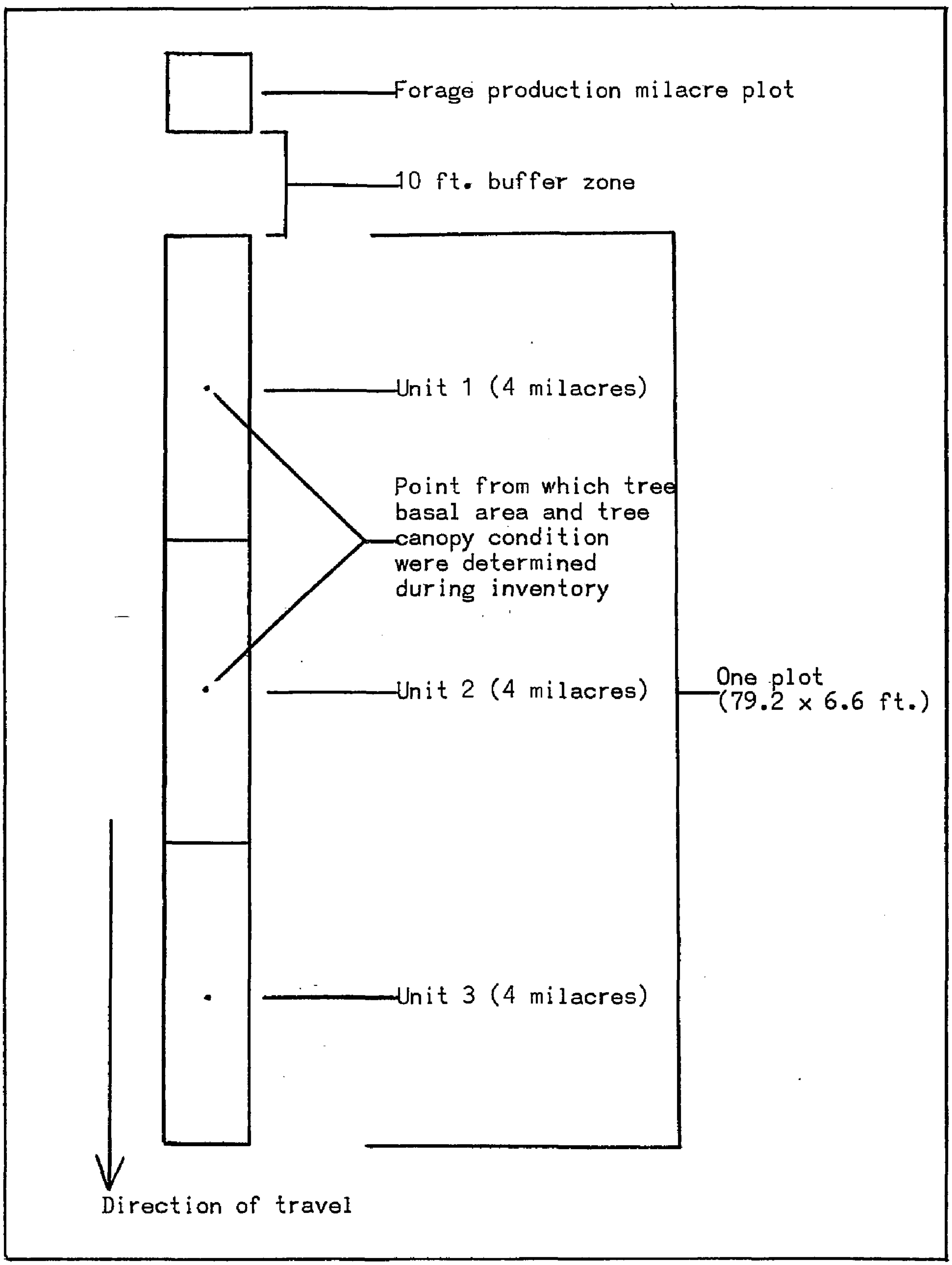


Figure 2. Plot layout in relation to permanent milacre forage production plots.

Plant inventory

An inventory of the selected deer-browse plants listed in Table 1 was made after all the units were located. Unit boundaries were marked with white plastic clothesline cord while making the inventory. Plants mature enough to produce fruit that originated within the unit boundaries were included in the inventory. Limbs from stems outside the units were disregarded. Stems that originated on the boundary lines were included in the inventory, if more than one-half the stem at ground level was inside the unit.

The total height, live crown depth, and crown width of all study plants except French mulberry, blackberry, and blueberry were determined to the nearest one-tenth foot. The stem diameter at breast height was measured to the nearest one-tenth inch on all study plants that had normal stems above that height. Inventory data were recorded on a IBM code sheet, then the plant was tagged with an aluminum tag stating the appropriate letter code for the species and the plant number.

It was impractical to make individual records of each French mulberry, blackberry, and blueberry plant due to the high number of stems per unit. The inventory of these plants consisted of counting the number of stems at ground level for each species and recording this with an average of all measurements. Stem diameter measurements were taken six inches above ground level. All values obtained in the field were recorded directly on code sheets. A summary of the plant inventory by closure units is presented in Tables 2 and 3.

Table 2. Number of plants tagged in each closure

	Closure number						
Plant species	1	2	3	4	5	6	Total
Dogwood	7	--	1	5	3	10	26
Parsley hawthorn	12	7	5	5	1	2	32
Hawthorn	16	22	25	11	3	5	82
Yaupon	--	1	--	--	1	8	10
Mexican plum	5	3	2	6	3	--	19
Tree huckleberry	24	12	19	12	8	7	82
Rusty blackhaw	6	3	1	--	--	--	10
Arrowwood	26	19	15	14	10	10	97
Muscadine	22	2	12	4	--	2	42

Table 3. Number of units on which untagged study plants occurred

	Closure number						
Plant species	1	2	3	4	5	6	Total
French mulberry	116	99	59	113	70	123	580
Blueberry	76	28	54	46	22	29	255
Blackberry	2	9	2	14	3	18	48

Tree basal area measurements were determined in 1963 from the center of each unit by using a "10-factor" wedge prism. All trees on or off the plots with a diameter at breast height above two inches were included in the basal area estimate; therefore, the general stand density of immediate area including the sampling unit was measured. No distinction was made between pine and hardwood during the basal-area inventory.

A visual method of coding the forest canopy condition was based primarily upon the crown classification system used by foresters. The absence or presence of tree canopy above the unit was first determined. If a canopy was present, two aspects of the canopy, position and composition, were taken into consideration. The tree canopy positions were divided into three groups according to tree size: (1) overstory canopy composed of mature saw timber trees, (2) multistory canopy of mature trees forming an overstory with a midstory of young or suppressed trees, and (3) midstory canopy of young tree crowns and/or stands from which the saw timber had been removed. Canopy composition, based on the presence of pine and/or hardwood trees which formed the canopy, was divided into three possible groups: (1) pine, (2) pine-hardwood, and (3) hardwood. With this coding system, the ten possible canopy conditions recognized in this study were:

First number: presence of canopy

01 - canopy absent

02 - canopy present

Second number: canopy position

01 - overstory

02 - multistory

03 - midstory

Third number: canopy composition

01 - pine

02 - pine-hardwood

03 - hardwood

As an example, a canopy code of 02-02-03 would describe a multistory hardwood forest canopy.

The soil type of each plot was determined from a soil type and capability map of the study area prepared by the U. S. Soil Conservation Service for the U. S. Forest Service. All data were recorded directly on IBM code sheets in order to eliminate the additional time required to transfer the data from field sheets to code sheets. This procedure also reduced the human error involved in transferring the data. The units are classified by tree basal area classes, tree canopy conditions, and soil types in Tables 4, 5, and 6.

Fruit collection and weighing

Fruit collections directly from the plants, which were initiated when the fruit began to mature, were completed as rapidly as possible in order that all the fruit of one species would be near the same stage of maturity. This procedure reduced to a minimum the loss from animal consumption and abscission. The fruits, except for those on the smaller plants, could not be eaten by deer until they fell to the ground; therefore, the loss of fruits from deer utilization was nil.

Fruit collected from each plant was placed in a separate plastic bag, except French mulberry and blueberry, which were collected on a

Table 4. Tree basal area on sampling units

Basal area in sq. ft. per acre	Number of units
30 or less	37
40	69
50	98
60	158
70	166
80	175
90	149
100	105
110	41
120	44
130 and above	38
Total	1080

Table 5. Canopy classification of sampling units

Canopy condition	Number of units
Absent	168
Overstory	
Pine	93
Pine-hardwood	70
Hardwood	33
Multistory	
Pine	1
Pine-hardwood	375
Hardwood	149
Midstory	
Pine	--
Pine-hardwood	20
Hardwood	171
Total	1080

Table 6. Soil type and slope of sampling units

Soil type	Per cent slope	Number of units
Beauregard	1-3	126
Beauregard	3-5	27
Bibb-Mantachie	0-5	42
Caddo	1-3	75
Cuthbert	1-3	180
Cuthbert	3-5	309
Cuthbert	5-20	117
Sawyer	1-3	96
Sawyer	3-5	18
Susquehanna	1-5	3
Susquehanna	5-20	33
Local alluvial	0	54
Bowie	1-3	0
Total		1080

sampling unit basis. All fruit on each unit was collected to decrease the possibility of making incorrect yield calculations. The same plastic bags used in the collections were used for storing the fruit under refrigeration until it could be weighed and dried. A label containing the date and closure, plot, unit, and plant number was placed in each bag and the bag was secured with a small piece of aluminum wire. A record of each sample was kept in a field book.

The field or fresh weight was determined for the total sample within a week of its removal from the study plant. Weights to the nearest 0.1 gram were determined on a Mettler balance and recorded in the field book and on the identification tags in the sample bags. If a fresh sample weighed over 50 grams, only 50 grams were retained for determining the oven-dry weight. When the fresh sample weights were less than 50 grams, the oven-dry weights were obtained from total samples. Individual samples were placed in aluminum cups along with their respective labels and dried at 85°C in a forced-air oven until the weight of a sample became constant. After oven-dry weights were obtained and recorded in the field book, the samples were stored in labeled envelopes until they could be prepared for chemical analyses. Oven-dry weights and per-acre fruit production were used in the analyses and discussion of the data unless otherwise indicated.

<u>Flower and fruit development</u>

Bi-monthly observations were made from initial flower growth until fruit abscission began. Whenever possible, the information on flowering period, time of fruit setting, fruit maturity, and abscission dates were obtained from the same plants but not from tagged plants.

Photographs were made of the flowers and fruits with a 35 mm camera each time the area was visited.

Chemical analyses

Oven-dry samples weighing four grams or more were ground in a Wiley Mill with a 20-mesh screen for chemical analysis. The chemical content of the fruit was determined with the aid and supervision of personnel of the Louisiana State University Feed and Fertilizer Laboratory. Materials and equipment necessary for making the chemical analyses were supplied by the Laboratory.

Phosphorus, potassium, and calcium contents were determined from a 2-gram sample weighed to the nearest milligram. This sample was placed in a crucible and ashed at 550°C for at least four hours. The ashed sample was allowed to cool, then 10 ml of 3M HCL were added, and this solution was heated on a hot plate until a visible vapor ascended from the solution. The sample was transferred to a 100 ml volumetric flask then distilled water was added to bring the sample solution to volume. The sample and water were thoroughly mixed and allowed to stand at least four hours. This aliquot was used to determine the phosphorus, potassium, and calcium content. It was possible to process about 60 individual samples simultaneously.

Phosphorus was determined by taking a 5-ml sample from the aliquot with a 5 ml pipette and placing it into a 50 ml volumetric flask. Ten ml of vanadomolybdate reagent were added to the 5-ml sample, then this solution was brought to volume with distilled water. Blanks, which were prepared at the same time, were read along with the samples. An optical density meter was used to measure the turbidity in determining the phosphorus content. Calculations were then made to determine the percentage of phosphorus in the sample.

The potassium and calcium contents were determined by removing a 10-ml sample from the aliquot with a 10 ml pipette and placing it in a 50 ml volumetric flask. One ml of 10 per cent $SrCl_2$ was added to the sample to mask interference of phosphates and sulphates when determining calcium by the atomic-absorption spectrophotometry method. The sample was then brought to volume by adding distilled water, and this solution was thoroughly mixed by shaking the stoppered flask.

Flame emission spectrophotometry was used to determine the amount of potassium by placing a small cup of the solution under the flame of the instrument so that some of the solution would be sucked into the flame and burned. An atomic-absorption spectrophotometry instrument was used to determine the calcium content. The percentages of potassium and calcium were calculated from curves drawn from blanks which were run with the samples.

The first step in the determination of crude protein content was to weigh a 1.4-gram sample to the nearest milligram. This sample was then transferred to a 500 ml Kjeldahl flask. A Kel-Pak containing the catalysts mercuric oxide and potassium was added to the flask. Twenty-five ml of concentrated sulfuric acid were then added, and the flask was placed on a digestion rack and allowed to digest at about 350°C for two hours. After 30 minutes, the flask was rotated 180°. After two hours digestion, the sample was allowed to cool about 15 minutes, then diluted with 150 ml of water, mixed, and allowed to stand about 30 minutes.

One hundred ml of four per cent H_3BO_3 with methyl purple indicator were added to a 500 ml filtering flask and rinsed down with distilled water. The filtering flask was placed on the distillation rack with the delivery tube below the surface of the solution. Three to five pieces of mossy zinc metal were added to the cooled sample, then the flask was placed on the distillation rack. Slowly, 100 ml of 50 per cent sodium hydroxide were added to the sample; the flask was stoppered and the solution was mixed. A water-cooled condenser was used to condense the vapor as the sample was distilled until the solution level was even with the ceramic refractory on which the flask rested. Extra precaution was taken to make sure none of the distilled material escaped the receiving flask.

The receiving or filtering flask was removed and the solution titrated with 0.1N NH_4OH. The amount of NH_4OH used in the titration was an indication of the sample's nitrogen content. Nitrogen per cent was calculated by determining the amount of acid neutralized by the nitrogen in the sample. Crude protein per cent was determined by multiplying the nitrogen content by 6.25, which is the standard conversion factor. Results of the chemical analysis are presented as percentages of oven-dry weight.

Analysis of data

The yield of the fruit per acre was determined for each plant species by tree basal area classes, tree canopy conditions, and soil types. All averages were computed from the 1080 units, not just from units which contained study plants or produced fruit. Combined fruit yields were determined by combining all fruit produced by the study plants growing on the units. In regression analyses, only those units containing plants of the particular species being studied were included.

Chemical content means and standard deviations were calculated for each species of fruit. Proximate crude protein, phosphorus, potassium, and calcium contents were determined from individual samples; therefore, it was possible to determine the mean and standard deviation for each year. Magnesium, iron, zinc, fat, fiber, and ash contents were determined from composite fruit samples of each species. Chemical content percentages were based on oven-dry weights.

Simple linear regression was used to test the effect of tree basal area (X) on fruit yield ($\hat{Y}$). The Research Computer Center of Louisiana State University also used the Variable Precision Multiple Regression Program to determine the possibility of a correlation between yield ($\hat{Y}$) in grams per unit and tree basal area (X_1) in square feet per acre and study plant diameter (X_2) to nearest 0.1 inch, height (X_3) to nearest foot, crown depth (X_4) and width (X_5) to nearest foot. Multiple regression equation for expected yield ($\hat{Y}$) were determined for all groups of data, which had sufficient observations to attempt an analysis, as the data were sorted by plant species, tree canopy conditions, and soil types.

The Computer Center used the same multiple regression program to determine the possibility of a correlation between variations in chemical content and tree canopy condition or soil type. The $\hat{Y}$ was determined for crude protein, phosphorus, potassium, and calcium content. Independent variables were identical with those used in the fruit yield calculations.

Results of the statistical analyses on total yields are presented in the section titled "Combined Yields".

Rainfall

According to the U. S. Weather Station at Winnfield, Louisiana, the rainfall from July 1, 1962 to June 30, 1963 was 37.28 inches; from July 1, 1963 to June 30, 1964 it was 50.04 inches. It was felt that these periods within the year would be influential on subsequent fruit yield.

FRUIT COLLECTIONS

The 1963 fruit collection was initiated on August 14 and completed on October 17. Spring collection of blueberry was made between May 21 and May 30, 1964. The remainder of the 1964 fruit was harvested from September 15 to October 27. It was felt that weights of damp fruit would be inconsistent; therefore, fruit collections were not made during rainy weather. Rain interrupted the collection of fall-maturing fruit both years.

A ladder was designed to aid in making total collections of fruit from the larger study plants. One-inch aluminum pipe and 1- by 1/8-inch aluminum bars were used in constructing the ladder. As seen in Figure 3, the ladder was designed so it could be transported easily through the dense underbrush present on parts of the research area. The ladder could be assembled and disassembled easily in the field because of the wing-nuts and U-bolts, yet it was sturdy. Figure 4 illustrates the use of the ladder in the field.

A plastic bag holder made by using two Number 12 Swingline binder clips and a piece of string allowed free use of both hands when picking fruit. The string was about 30 inches long with a binder clip attached to each end. This was placed around the picker's neck to hold the plastic bag while the fruit was collected. A label was placed with each sample, then the bag was detached from the binder clips and secured with a short piece of aluminum wire. This method of holding the bags while picking the fruit reduced the collection time considerably.

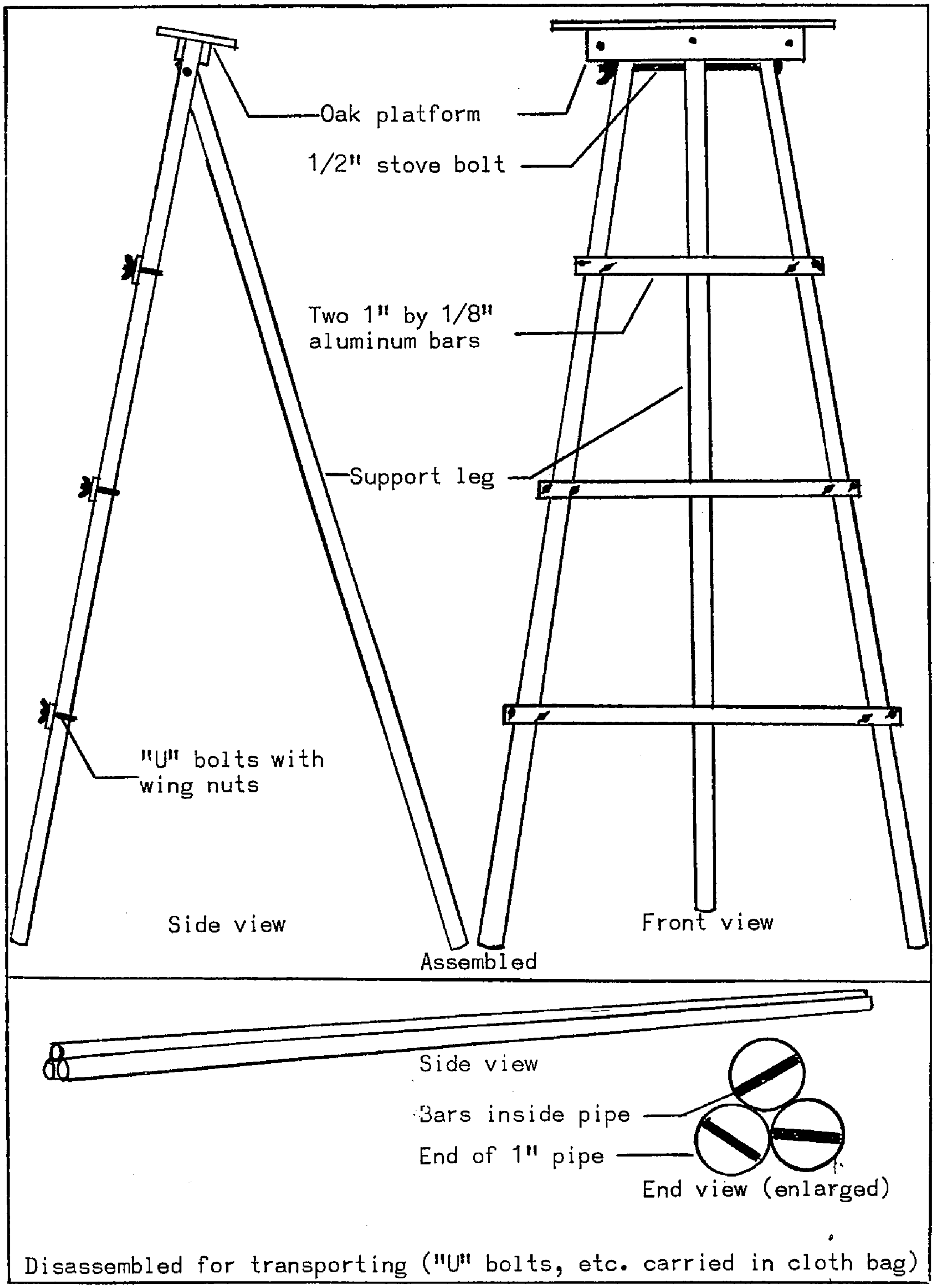
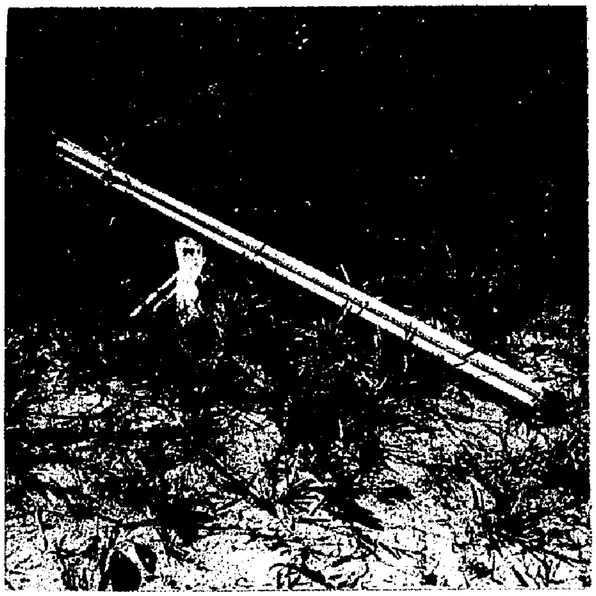


Figure 3. Ladder constructed to use in collection of fruit.

Figure 4. Ladder designed for and used in collecting fruit from larger plants. Photographs by Dr. Bryant A. Bateman.

Top left:	Disassembled for carrying.
Top right:	Ladder being assembled for use.
Bottom left:	Assembled ladder and stick with wire hook used in pulling branches to picker.
Bottom right:	Picking fruit of yaupon.



The collected fruits were placed under refrigeration until they could be returned to the Louisiana State University campus, where they were processed. All samples were weighed within a week after collection and were kept under refrigeration until they could be dried in the forced-air oven.

FRENCH MULBERRY

Plant description

French mulberry (Callicarpa americana L.) of the Verbenaceae is usually found growing on the upland soils of the southeast which support southern pines. This much-branched shrub grows to a height of eight to nine feet, but the average height is about four feet. Many stems or branches often originate from a common root collar.

The dichotomous flower clusters are located in the leaf axils, and their color may range from rose to pink or pale blue. Expanded clusters of berry-like drupes that are located in the leaf axils are usually conspicuous, especially when they turn to a rose, purple, or violet color as they ripen. The simple, deciduous, pubescent leaves are opposite or whorled. The leaves and flowers are located on the current year's stem growth.

French mulberry is a shade-tolerant shrub which grows under almost any type of upland forest cover. Habitat conditions are best under open, mature southern pine stands where there is little competition from other shrubs. French mulberry leaves wilt during extended drought because of its shallow root system, but it can be found on very dry sites.

Animals known to utilize the fruit or foliage and stems are game and non-game birds, raccoon, opossum (Didelphis virginiana), fox, deer, rabbit, and some domestic livestock. The plant is fairly tolerant to browsing, as it recovers rapidly from as much as a 40 per cent loss from animal utilization.

Flowering and fruiting

A notebook record, which was kept on all the study plants, provides a rough sequence of the flower and fruit development. By mid-April, small leaves and new shoot growth were visible. Two weeks later some of the leaves were of normal size, but no flower buds were visible. Small flower buds were visible in the axils of the older leaves by the end of the first week in May. The leaves were progressively smaller toward the growing tips of the stems. The flower buds increased in size until they began to open just before mid-June. By mid-July, all the flowers except those near tips of actively growing stems had disappeared and small fruit could be seen. The fruit grew rapidly until it began to mature in mid-August. All the fruit found on the study area was mature by October 1. Pictures showing the flower and fruit development during the spring, summer, and fall of 1964 are presented in Figures 7 and 8.

Mature fruit remained on the plants until the first hard freezes in December, even though the leaves had begun falling by November. The fruit began turning brown and shrivelling in December. Toward the end of December, the fruit was very scarce, and by mid-January none could be found.

Fruit yield

The average yield of French mulberry fruit on the study area was 832.7 grams per acre in 1963 compared to 2,590.0 grams in 1964. This difference in yield could have been due to the variation in rainfall between the two years as the plants were in a flaccid condition during much of the 1963 growing season. The fruit moisture content of 81.7

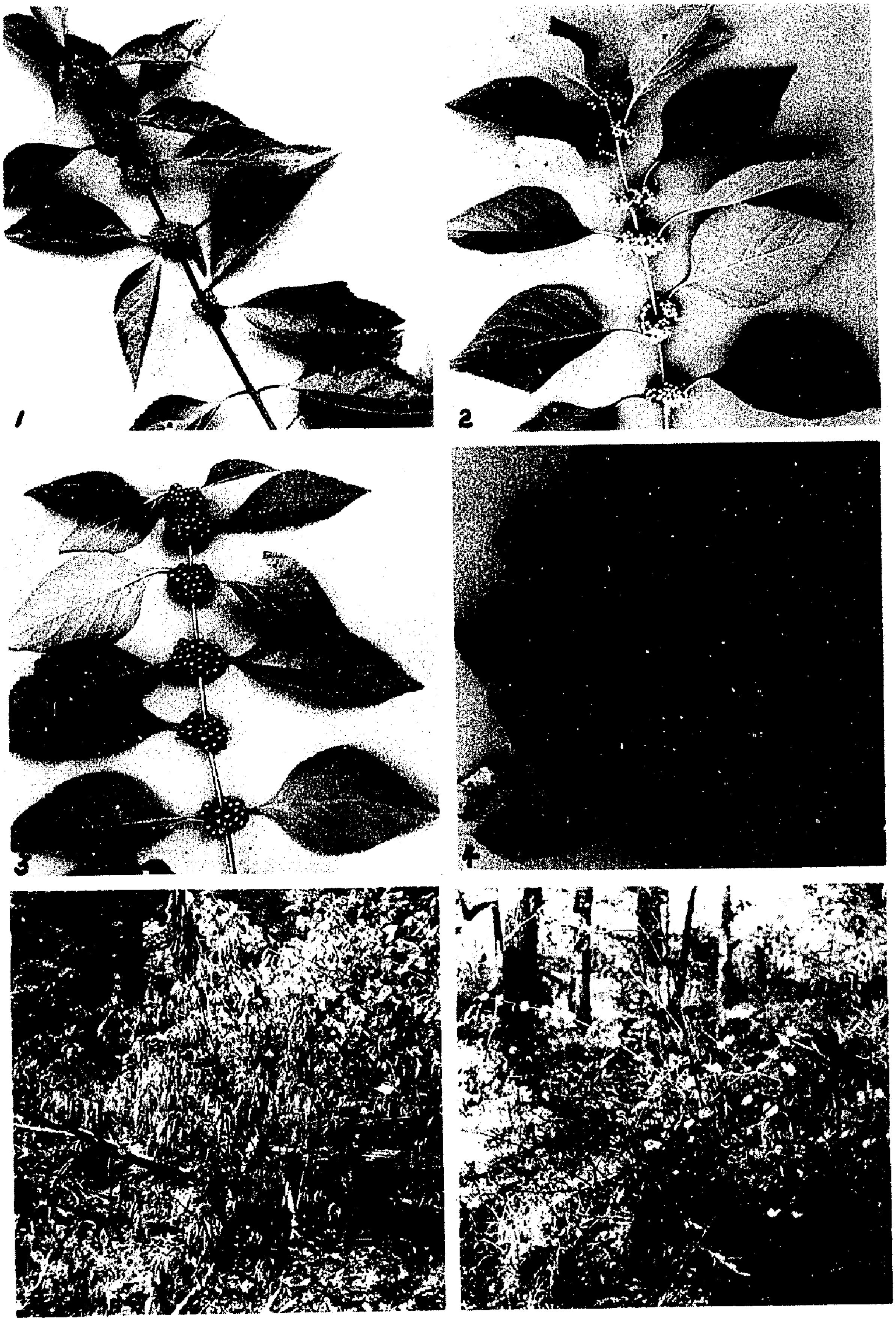
Figure 5. Flower and fruit development of French mulberry, 1964.

1. Dormant plant, March 27.
2. Young growing leaves, no flower buds visible, April 24.
3. Young leaves with flower buds visible in axils, May 8.
4. Flower bud clusters visible in leaf axils, May 28.
5. Flowers present in leaf axils, June 15.
6. New fruit crop, July 3.


3
4
5
6

Figure 6. Flower and fruit development of French mulberry, 1964 (continued).

1. Immature fruit, July 17.
2. Immature fruit, August 1.
3. Fruit beginning to mature, August 17.
4. Mature fruit, September 5.
5. Wilted plant on study area, August 17.
6. Plant with mature fruit after leaves had fallen, October 20.



per cent for 1964 was slightly higher than the 77.3 per cent of the previous year. Total fruit collections, yield per acre, and moisture content by years are presented in Table 7.

Table 7. French mulberry fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	15,875.15	61,211.40	3,675.0	14,175.0
Dry weight, grams	3,597.44	11,185.79	832.5	2,590.0
Per cent moisture	77.3	81.7		

There were 580 sampling units with plants, and fruit was collected on 255 of them in 1963 and 528 the following year. A comparison of the units with plants producing fruit was made with total units within each closure and with units that had plants (Table 8). The comparisons were made on a numerical and percentage basis. On the research area, 53.7 per cent of the sampling units had plants on them, and in 1963, 44.0 per cent of these units had plants that produced fruit; whereas, in 1964 the percentage was 91. On a closure basis, the percentages varied from 30.5 to 51.3 in 1963 and 87.7 to 100.0 in 1964.

The yield of fruit, on a unit and plant stem basis, also varied between years, as shown in Table 9. Average production of plants that produced fruit was 4.32 grams per plant in 1963 compared to 5.15 the following year. The number of stems producing fruit was much greater

Table 8. Summary of units with French mulberry that produced fruit

Closure	Units				Per cent of total units			Per cent of units with plants that produced fruit	
	Total	With plants	With fruit 1963	With fruit 1964	With plants	With fruit 1963	With fruit 1964	1963	1964
Enclosure 1	216	116	43	109	53.7	19.9	50.4	37.0	94.0
Exclosure 2	144	99	48	90	62.5	33.3	60.8	48.5	90.9
Exclosure 3	144	59	18	59	41.0	12.5	41.0	30.5	100.0
Enclosure 4	216	113	58	102	52.3	26.9	47.2	51.3	90.3
Exclosure 5	144	70	26	65	48.6	18.1	45.1	37.1	92.9
Enclosure 6	216	123	63	103	56.9	29.1	47.7	51.2	83.7
Enclosures	648	352	164	314	54.3	25.1	48.5	46.3	89.2
Exclosures	432	228	92	214	52.8	21.2	49.5	40.4	93.9
Total	1080	580	256	528	53.7	23.6	48.9	44.0	91.0

Table 9. Average oven-dry yields of units and plants that produced French mulberry fruit

Closure	Number of units		Number of stems		Total yield		Average yields: Per unit		Average yields: Per stem	
	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964
					(Grams)	(Grams)	(Grams)	(Grams)	(Grams)	(Grams)
Enclosure 1	43	109	112	475	755.2	2,078.7	17.56	19.07	6.74	4.37
Exclosure 2	48	90	179	421	1,012.5	2,916.4	21.09	32.40	6.22	6.93
Exclosure 3	18	59	57	207	263.0	1,043.5	14.61	17.68	4.61	5.07
Enclosure 4	58	102	215	422	825.8	1,854.4	14.24	18.18	3.84	4.39
Exclosure 5	26	65	66	245	144.0	1,389.1	5.53	21.37	2.18	5.67
Enclosure 6	63	103	207	413	867.3	1,946.6	13.77	18.90	4.19	4.71
Enclosures	163	314	534	1310	2,448.3	5,879.7	15.02	18.73	4.59	4.49
Exclosures	92	214	301	873	1,419.5	5,349.0	15.42	25.00	4.72	6.13
Total & means	255	528	835	2183	3,867.8	11,228.7	15.16	21.27	4.63	5.15

in 1964 than the previous year; therefore, the total yield of fruit was over three times greater in 1964 than in 1963. The yields were 11,185.79 grams and 3,597.44 grams respectively. This illustrates the wide variation of fruit production under natural conditions.

All sampling units were used in determining the average yield for each basal area class. Units with a tree basal area of 30 square feet or below were grouped together, and those with basal areas of 130 and above were combined into one group. French mulberry produced fruit under all basal area classes both years, as seen in Table 10. The highest yields in 1963 were in the lowest basal area range, but the following year the most fruit was produced under a 40 square-foot basal area stand. Fruit production was less than average on all units with a basal area greater than 60 square feet in 1963 and 70 square feet in 1964. As the basal area increased, the variation in fruit yields between years also increased.

Regression analysis was used to determine the relationship between fruit yield ($\hat{Y}$) and tree basal area (X). The results, shown in Figures 5 and 6, indicate that a definite relationship exists, and a _t_-test proved that this relationship was statistically significant (P = .05) both years. The coefficient of determination, .042 for 1963 and .033 for 1964, show that basal area accounted for only a small part of the variations in fruit yields; therefore, the formulas cannot be used to predict yields with any degree of reliability.

Multiple regression was resorted to in an attempt to account for more of the variations in fruit yields. The five independent variables described in the methods and procedures section were used in the

Table 10. French mulberry fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year	
	1963	1964
30 and below	3,717.5	4,575.0
40	2,562.5	5,137.5
50	960.0	2,387.5
60	1,132.5	3,127.5
70	760.0	2,787.5
80	447.5	2,267.5
90	755.0	2,357.5
100	157.5	1,777.5
110	207.5	1,602.5
120	105.0	1,115.0
130+	135.0	837.5
Average	832.5	2,590.0

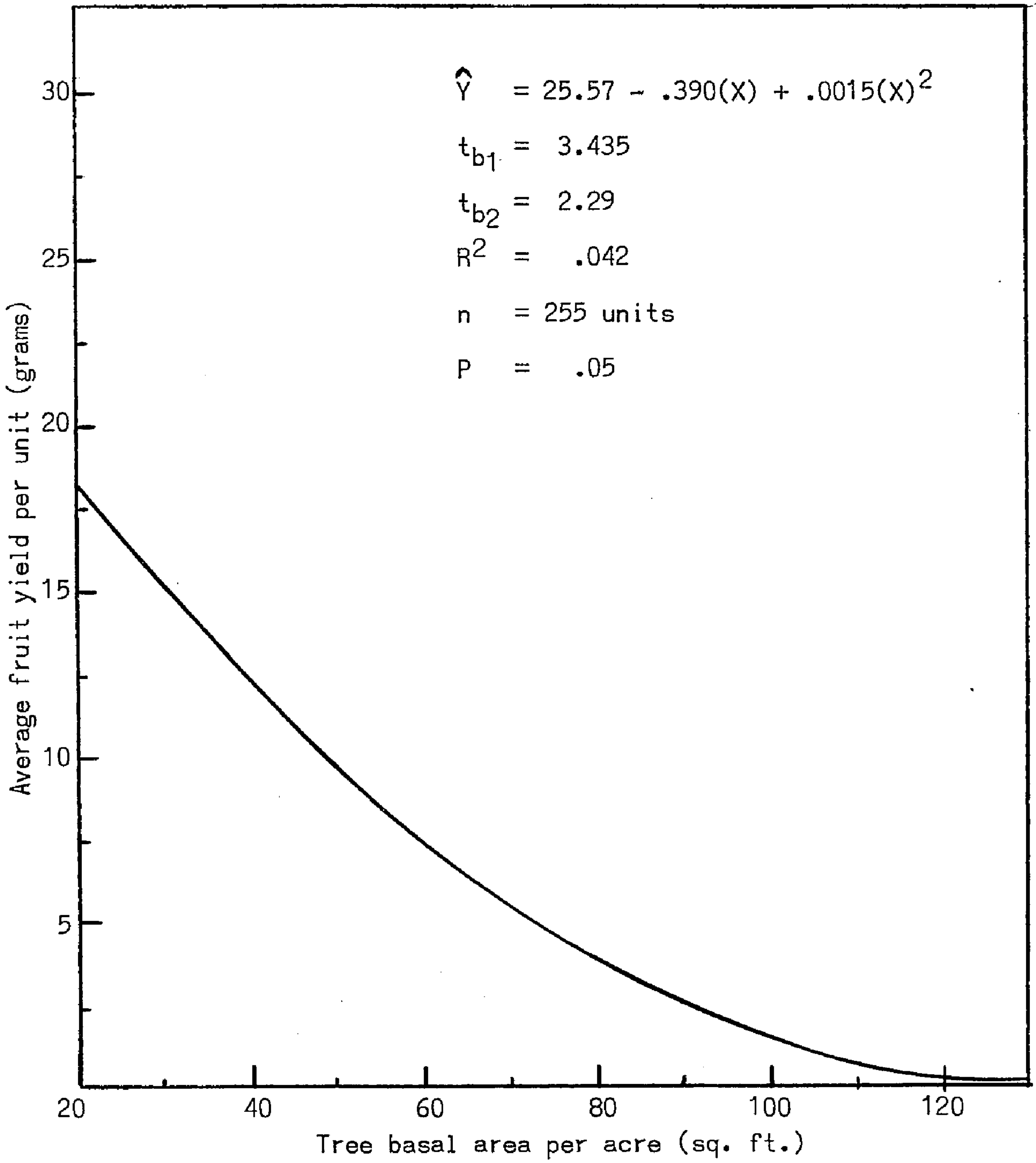


Figure 7. French mulberry fruit yield/tree basal area relationship, 1963.

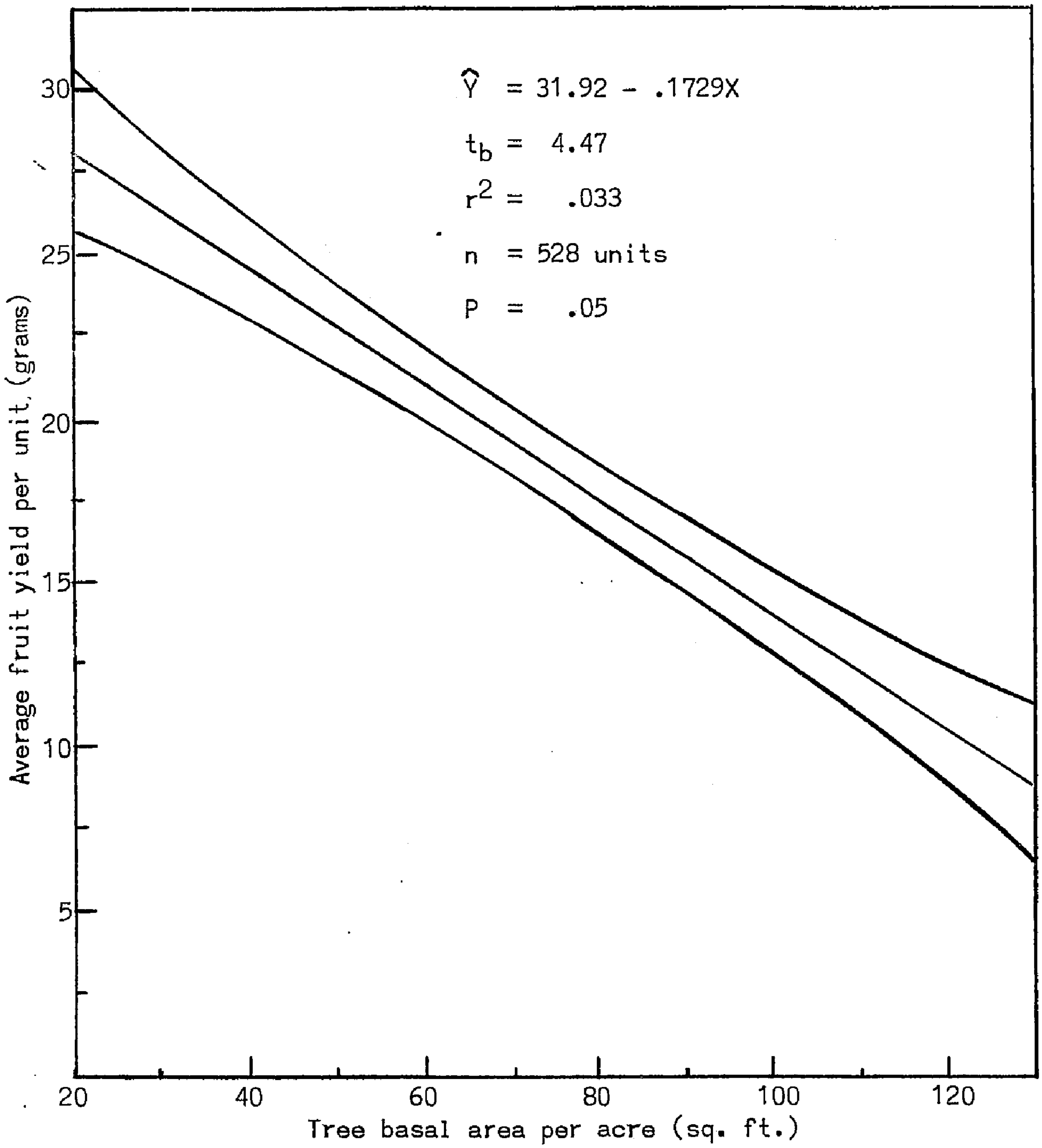


Figure 8. French mulberry fruit yield/tree basal area relationship, 1964, with confidence limits at 5 per cent level.

analysis. Formulas derived from the analysis are as follows:

$$1963 \quad \hat{Y} = -37.5 - 1.03X_1 + 35.46X_2 + 1.17X_3 - 0.17X_4 + 1.75X_5.$$

$$1964 \quad \hat{Y} = -55.0 - 1.05X_1 + 81.59X_2 + 1.91X_3 + 3.09X_4 - 9.99X_5.$$

This analysis accounted for more of the fruit yield variations, but the R^2 values, .14 for 1963 and .22 the following year, indicated that the formulas cannot be used to estimate fruit yields accurately.

When the average yield per acre was determined according to tree canopy condition, the effect of sunlight interception and diffusion upon the ability of the plants to produce fruit should be indicated. With French mulberry, the best yields were obtained when the canopy was absent or present as an overstory, as shown in Table 11. Where a canopy existed, the best fruit production occurred both years under an overstory of pine. The lowest yields were obtained under multistoried hardwoods. Above-average yields were obtained in 1963 when the canopy was absent or when an overstory of pine existed. Plants growing in the openings and under all overstory conditions produced better than average fruit yields in 1964. From this study, it seemed that the highest to the lowest average yields of fruit were in the following order: canopy absent, overstory canopy, midstory canopy, then multistory canopy.

Fruit yield per acre by soil types indicated that the primary factors affecting yield for the two-year period were per cent slope and sand content of the soil. Two soils, the Bibb-Mantachie and local alluvial, had very little or no slope, and yields on these two soils were approximately equal each year. Yields on Bibb-Mantachie soils

Table 11. French mulberry fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	2,977.5	6,500.0
Overstory		
Pine	1,145.0	4,210.0
Pine-hardwood	580.0	3,267.5
Hardwood	465.0	2,792.5
Multistory		
Pine	-- *	--
Pine-hardwood	230.0	1,352.5
Hardwood	227.5	952.5
Midstory		
Pine	--	--
Pine-hardwood	500.0	2,440.0
Hardwood	625.0	1,720.0
Average	823.5	2,590.0

* The "--" mean no sampling units or inventoried study plants occurred and "0" indicates no yield when units or plants were present.

for 1963 and 1964 averaged 680.0 and 1,077.5 grams per acre respectively; whereas, the yields on local alluvial soils averaged 530.0 and 1,135.0 grams per acre. Three soil types had yields in 1964 that were over five times greater than the 1963 yields. A comparison of the soils indicated that these soils had lower water retention properties because of rapid profile percolation or surface run-off. The Cuthbert (5-20 per cent slope) and the two Sawyer soils, as shown in Table 12, had the widest variation in fruit yield per acre between years. Although all soil types increased in yield the second year, the increase was less spectacular for some soil types. This seems to indicate that the water retention capacity of the soil could have some effect on the fruit yield of French mulberry.

Chemical content

The per cent of crude protein, phosphorus, potassium, and calcium in the oven-dry fruit of French mulberry was obtained from 573 individual samples analyzed in the laboratory. One hundred and forty-five of these samples were collected in 1963, and the remaining 428 were obtained in 1964. A summary of the chemical analyses by means and standard deviations for each year is presented in Table 13. Although the chemical contents varied widely, grouping the samples by tree density, canopy condition, or soil type did not indicate a trend based upon these factors.

The fruit yields were higher in 1964, but the chemical content percentages were slightly higher in 1963. Chemical content means for the two years were: crude protein, 5.335 per cent; phosphorus, .1183 per cent; potassium, 1.321 per cent; and calcium, .250 per cent.

Table 12. French mulberry fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1–3	750.0	3,322.5
Beauregard	3–5	1,822.5	4,985.0
Bibb-Mantachie	0–1	680.0	1,077.5
Caddo	1–3	1,845.0	3,045.0
Cuthbert	1–3	1,580.0	3,635.0
Cuthbert	3–5	720.0	2,277.5
Cuthbert	5–20	127.5	1,575.0
Sawyer	1–3	267.5	3,162.5
Sawyer	3–5	27.5	1,565.0
Susquehanna	5–20	367.5	887.5
Local alluvial	0	530.0	1,135.0
Average		832.5	2,590.0

Table 13. Proximate chemical content of French mulberry fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	5.83	5.16	0.82	0.53
Phosphorus	.127	.115	.02	.016
Potassium	1.36	1.31	.16	.14
Calcium	.28	.24	.06	.10

FLOWERING DOGWOOD

Plant description

Flowering dogwood (Cornus florida L.) of the Cornaceae is a small understory deciduous tree which grows to a height of about 40 feet. The range is rather extensive as the species can be found throughout the eastern half of the United States from Minnesota to East Texas and eastward to the Atlantic coast.

The greenish-white flowers are perfect and are found in dense terminal clusters which are subtended by four white or pink bracts that most people mistakenly call petals. As the clustered drupes mature, they change from green to bright red. The leaves are simple, opposite, and strongly petioled. They are bright green on the upper surface and very pale and pubescent below.

Usually, flowering dogwood is found as an understory plant on moist, well-drained sites. It is especially noticeable on recently cutover areas, but normally is found under a forest canopy. Dogwood is very tolerant but will grow more rapidly and produce a fuller crown when grown in open stands. The shallow rooting habit makes it vulnerable to extended droughts.

The fruit is eaten by at least 28 species of birds, including the bobwhite quail (Colinus virginianus) and turkey. Squirrels and deer are known to feed on the fruit. It is also considered a desirable browse for deer, especially young plants and sprouts. Besides its value to wildlife, flowering dogwood has become an important native ornamental.

Flowering and fruiting

Flower buds are very conspicuous on the plants in the fall, before the mature fruit and leaf abscission begins. The spring growing season for 1964 started between late-March and mid-April as all plants did not break dormancy at the same time. All the flower bracts were gone by April 24, and the new fruit crop was "set". By early May, two sizes of fruit could be detected on the fruiting stem. Evidently, some flowers did not successfully pollinate since the size of some fruit increased little, if any, during the normal growing season. The other fruit continued to grow rapidly until about mid-July, and additional growth was not apparent after that time.

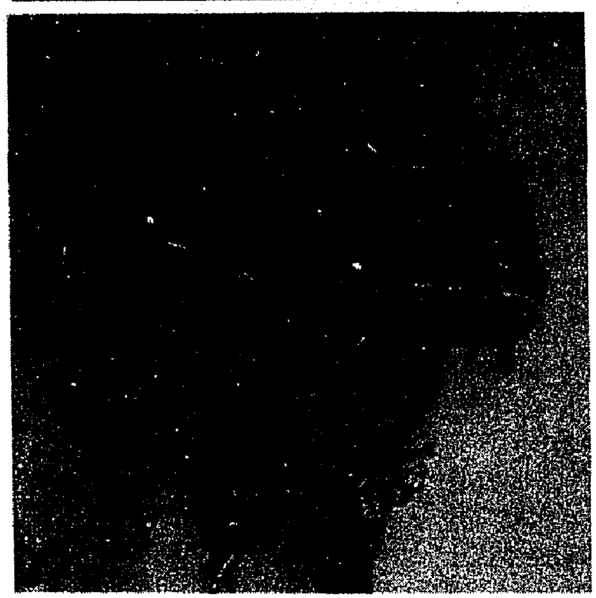
A change in fruit color was detected the first of September as the color gradually changed from green to reddish-green then red, and all the visible fruit was mature by mid-October. The fruit became less firmly attached in late November when an abscission layer began to form. By the second week of December, all the fruit had dropped and the dormant flower buds were prominent again. A pictorial development of the fruit is presented in Figures 9 and 10.

Fruit yield

Flowering dogwood ranked fourth in fruit production during 1963 and second in 1964. The average yield of dry fruit was 227.5 grams per acre in 1963 and 482.5 grams per acre in 1964. The only noticeable reason for this difference was the more nearly normal rainfall

Figure 9. Flower and fruit development of flowering dogwood, 1964.

1. Plant in full bloom, March 27.
2. Dogwood flower and young leaves, April 10.
3. New fruit crop, April 24.
4. Clusters of immature fruit. Two sizes can be distinguished, May 8.
5. Immature fruit, May 28.



4

5

Figure 10. Flower and fruit development of flowering dogwood, 1964 (continued).

1. Immature fruit, showing two sizes, June 15
2. Immature fruit, July 3.
3. Immature fruit at almost mature size, July 17.
4. Immature fruit, August 17.
5. Immature fruit, but beginning to mature, September 5.
6. Mature fruit and flower bud, October 20.

in 1964. Total collections, average yields per acre, and moisture percentages for the two years are presented in Table 14. Fruit yield per plant averaged 35.2 grams in 1963 and 74.4 grams the following year.

Table 14. Flowering dogwood fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	1,834.4	4,272.9	425.0	987.5
Dry weight, grams	985.7	2,082.8	227.5	482.5
Per cent moisture	46.3	51.3		

Yield analysis by multiple regression was made to determine the influence of the independent variables upon fruit yield. Formulas obtained for the two years are:

1963 $\hat{Y} = 1458.3 - 1.2X_1 + 15.2X_2 - 0.3X_3 + 23.8X_4 + 115.6X_5.$

1964 $\hat{Y} = 83.8 - 20.2X_1 + 0.7X_2 + 10.4X_3 + 91.7X_4 + 382.3X_5.$

The R^2 value was 0.36 for 1963 and 0.25 for the next year, which indicates that the formulas would not make accurate yield predictions.

Average yields by tree basal area classes are presented in Table 15. For the two-year period, the best production was obtained under a stand which had a basal area of 80 square feet. The best individual yield was 3,005.5 grams per acre in 1964 under a forest that had a basal area of 40 square feet. Most of this yield was obtained from

Table 15. Flowering dogwood fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year 1963	Year 1964
30 and below	50.8	30.5
40	162.3	3,005.5
50	--	--
60	36.0	227.8
70	267.8	191.0
80	733.8	878.8
90	317.5	385.8
100	62.5	316.5
110	--	--
120	0	0
130+	--	--
Average	227.5	482.5

one plant which had an exceptionally large fruit crop.

The effect of tree canopy condition upon the yield of flowering dogwood fruit is shown in Table 16. Highest yields were obtained when an overstory of pine or hardwood existed. In 1963, the highest yield, 3,110.5 grams per acre, was produced under a hardwood overstory. The highest yield of 2,536.3 grams per acre for 1964 also occurred under a hardwood overstory. Fruit was produced under all canopy conditions both years, but all above-average yields were obtained under an overstory canopy. Better yields were obtained when the canopy was multistoried than when present as a midstory. There were indications that better fruiting conditions existed under a forest canopy since plants without an overhead canopy produced below-average yields both years. The lowest fruit production was obtained under a midstory hardwood condition.

Flowering dogwood fruit yields by soil types are presented in Table 17. Plants on the Cuthbert soils with a 5-20 per cent slope produced the most consistent crops. The yield per acre on this soil was 1,323.3 grams in 1963 and 1,419.5 grams for 1964. The highest yield per acre, 3,840.3 grams, was obtained in 1964 on the local alluvial soil. The Beauregard (3-5 per cent slope) and Cuthbert (5-20 per cent slope) produced above-average fruit crops in 1963. In 1964, above-average crops were produced on Cuthbert (1-3 and 5-20 per cent slopes), Sawyer (3-5 per cent slope), and local alluvial soils. Except for the Beauregard type, the best yields were obtained on the same soil types, although there was a great variation between years.

Table 16. Flowering dogwood fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	192.5	134.5
Overstory		
Pine	497.5	2,274.8
Pine-hardwood	139.8	484.8
Hardwood	3,110.5	2,536.3
Multistory		
Pine	--	--
Pine-hardwood	190.5	336.5
Hardwood	49.5	232.0
Midstory		
Pine	--	--
Pine-hardwood	175.0	168.8
Hardwood	7.8	28.5
Average	227.5	482.5

Table 17. Flowering dogwood fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1-3	6.0	0
Beauregard	3-5	725.0	0
Bibb-Mantachie	0-1	--	--
Caddo	1-3	184.0	111.3
Cuthbert	1-3	182.0	485.3
Cuthbert	3-5	10.5	73.0
Cuthbert	5-20	1,323.3	1,419.5
Sawyer	1-3	42.5	86.0
Sawyer	3-5	164.0	1,089.0
Susquehanna	5-20	44.8	34.0
Local alluvial	0	224.5	3,840.3
Average		227.5	482.5

Chemical content

The chemical analyses of flowering dogwood fruit were based upon 33 samples, 17 obtained in 1963 and 16 in 1964. There was some difference in mean percentages of crude protein, phosphorus, potassium, and calcium between years, and the standard deviations indicated variations in samples within each year (Table 18). The mean chemical contents of the 33 samples were: crude protein, 5.725 per cent; phosphorus, .124 per cent; potassium, .895 per cent; and calcium, 1.60 per cent.

Table 18. Proximate chemical content of flowering dogwood fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	6.06	5.74	0.82	0.87
Phosphorus	.132	.121	.033	.031
Potassium	.87	.96	.14	.17
Calcium	1.73	1.57	.36	.36

HAWTHORN

Plant description

The hawthorns (Crataegus spp.) of the Rosaceae are regarded by taxonomists as being unstable because of many natural hybrids. This is a large genus which has a range that covers most of the Northern Hemisphere, but it is most abundant in northeastern and central North America. Hawthorns exist as shrubs or small trees under a wide range of climatic and site conditions.

The normally white flowers are borne in many-flowered corymbs and are perfect. Hawthorn fruit may be a red, yellow, or black pome according to the species and variety. The leaves are deciduous and vary in size, shape, margin, and surface characteristics even within a given species. Hawthorns have simple serrate or lobed leaves.

Hawthorns are small trees or shrubs which usually have crooked, thorny branches. They may form dense thickets on exposed areas or be found as widely scattered individual plants. The genus has a wide range of shade tolerance. Species in this genus can be found growing under almost all types of habitat conditions from poorly drained sites to dry, rocky, sandy ridges and from exposed areas to sites under virgin forests.

Hawthorns are important as game food and cover. The fruits are utilized by many birds and animals, and current season twigs and foliage are browsed by deer. Some hawthorns are desirable as ornamentals, especially in parks and gardens.

Flowering and fruiting

The flowers of hawthorn began opening during the first week of April, about the same time new leaves began to grow. By the first week of May, all the flowers were gone; the new fruit had "set", and the leaves were about normal size. Figures 11 and 12 illustrate the flower and fruit development of parsley hawthorn, and Figures 13 and 14 are representative of the other hawthorns found on the study area. After a period of rapid growth from May to mid-July, the fruit size did not change appreciably until it matured in September. Field observations indicated that some fruit dropped about the first of August while still green, and some of the worm-infested fruit began to change color prematurely and fall a month later. Entire crops on some plants were lost at this time due to insect infestation.

All remaining fruit had matured by mid-October, and some was found on the plants until the last week of December. Most of the leaves had fallen a month earlier.

Fruit yield

Parsley hawthorn (*Crataegus marshallii* Egglest.) fruit yield was discussed separate from the other species of hawthorns until the average fruit yields were calculated for tree basal area classes, tree canopy conditions, and soil types. Total fruit collections were 337.1 grams in 1963 and 45.1 grams in 1964. This represents a per acre yield of 78.0 and 10.5 grams for the two years. The crop of fruit produced by the other hawthorns also varied greatly between years, averaging 119.8 grams per acre in 1963 and 9.0 grams the following year. Hawthorns, as a group, produced a fruit crop of 188.5 grams per

Figure 11. Flower and fruit development of parsley hawthorn, 1964.

1. Plant in full bloom, April 10.
2. Stem showing immature leaves and flower buds, March 27.
3. Young leaves and flowers, April 10.
4. Young fruit, April 24.
5. Young fruit, May 8.
6. Young fruit, May 28.

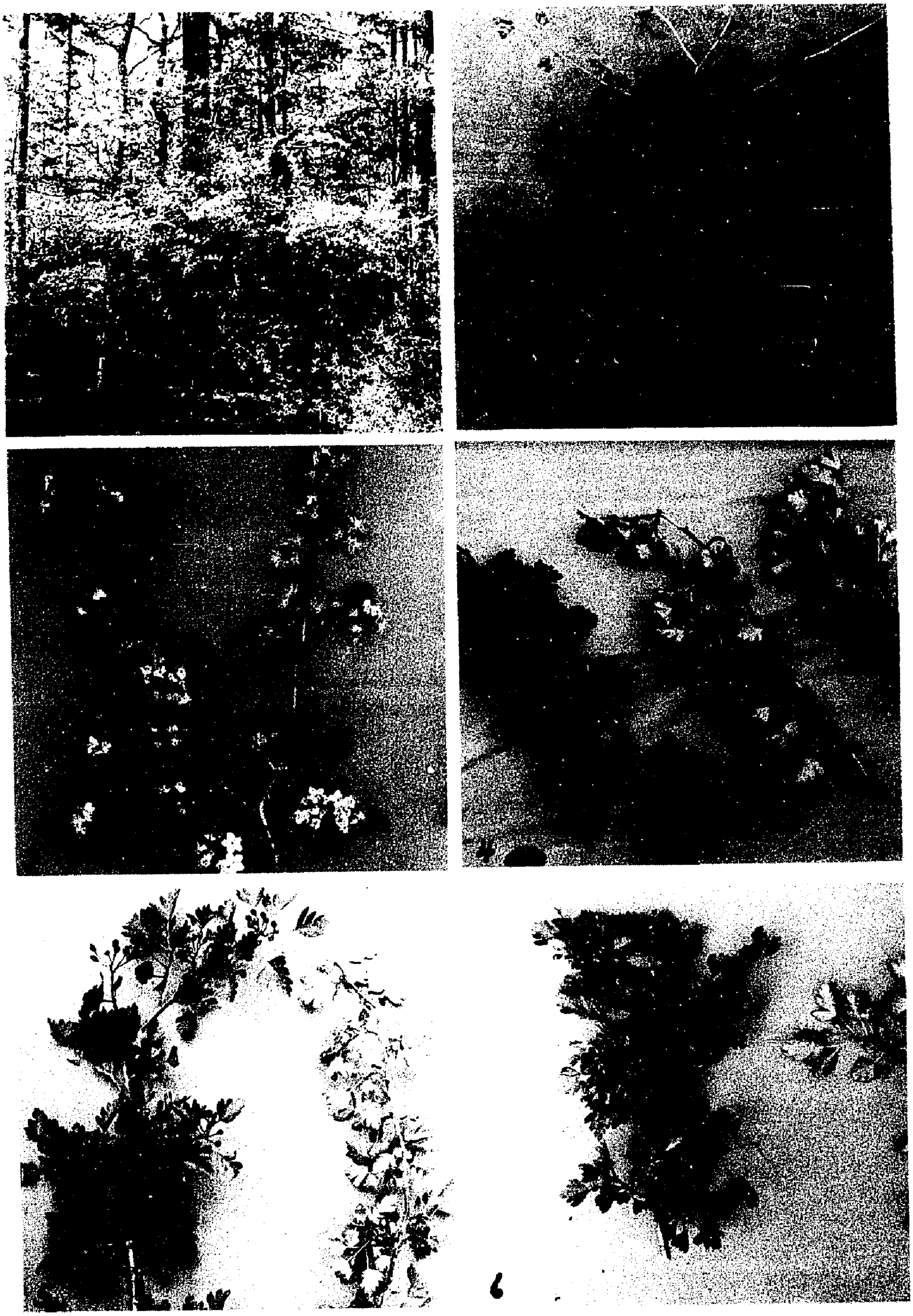


Figure 12. Flower and fruit development of parsley hawthorn, 1964 (continued).

1. Immature fruit, June 15.

2. Immature fruit, July 3.

3. Immature fruit, July 17.

4. Immature fruit, August 17.

5. Immature fruit, some color change detected, September 5.

6. Mature fruit, October 20.

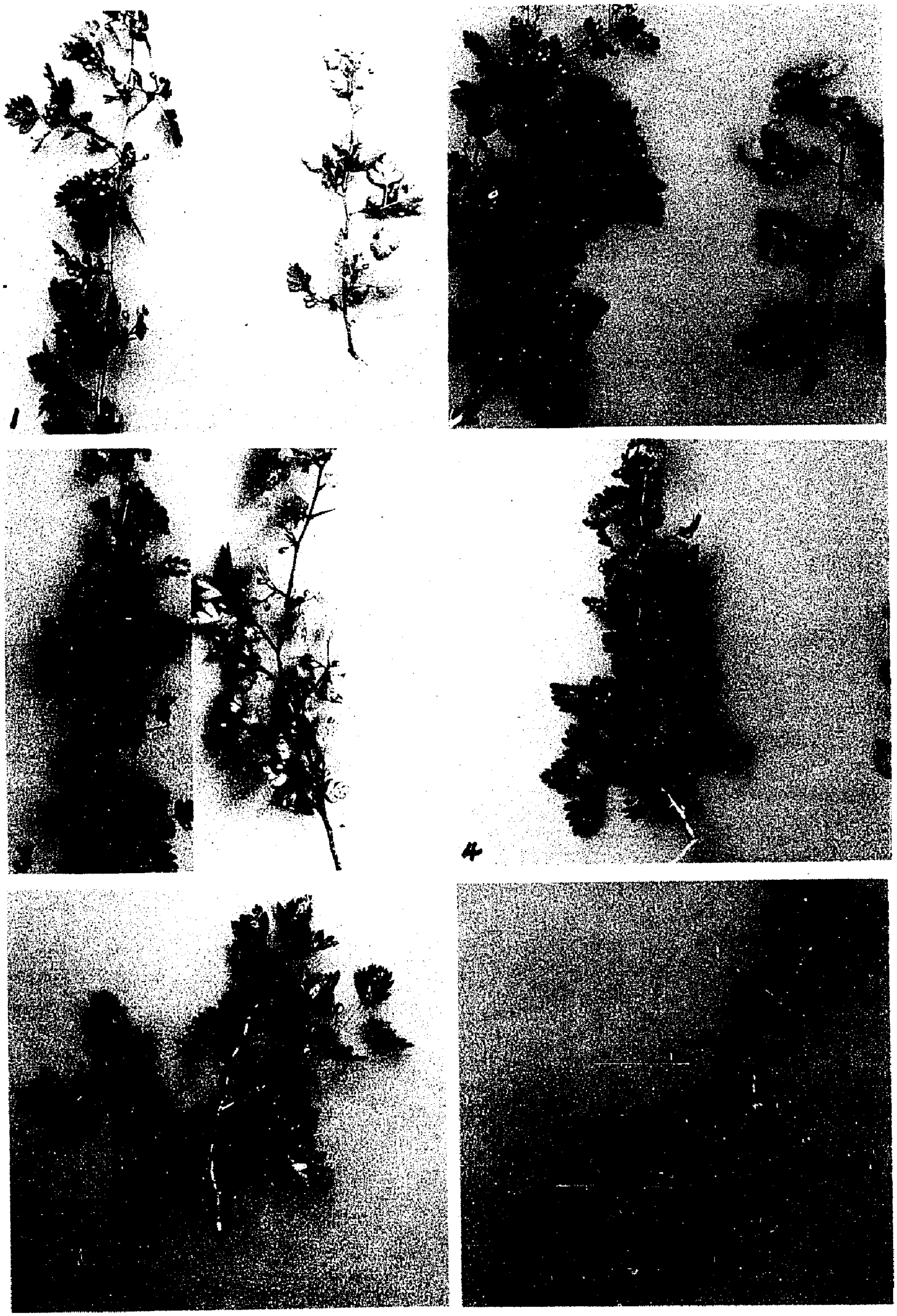
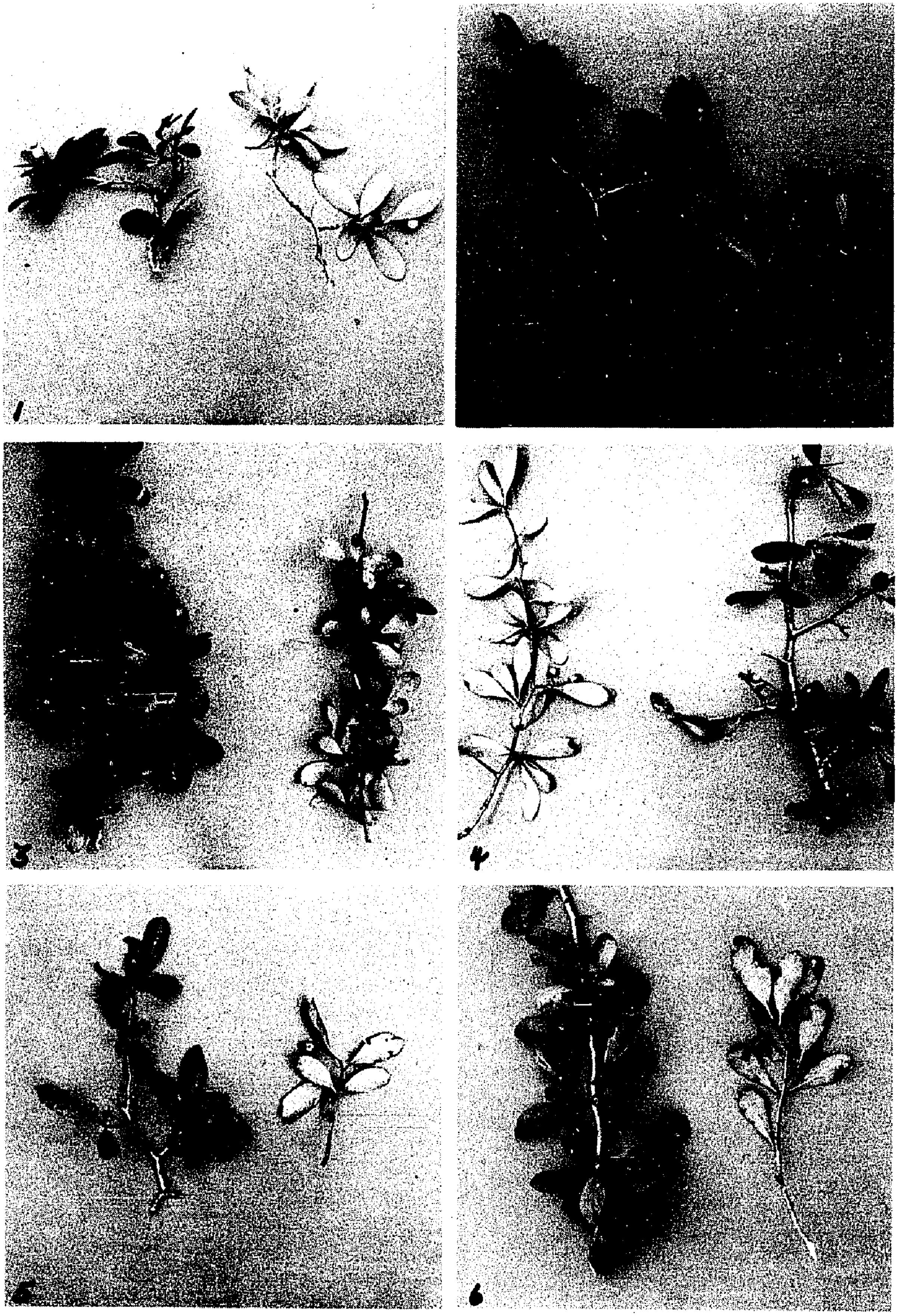


Figure 13. Flower and fruit development of hawthorn, 1964.

1. Dormant plant, March 27.
2. Stem showing flower buds and new leaves, April 10.
3. Flowers from which most of petals have fallen, April 24.
4. New fruit crop, compare with number of flower buds in picture number 2, May 8.
5. Immature fruit, May 28.

Figure 14. Flower and fruit development of hawthorn, 1964 (continued).

1. Immature fruit, June 15.
2. Immature fruit, July 3.
3. Immature fruit with one showing insect damage, July 17.
4. Immature fruit, August 17.
5. Immature fruit with insect damage spots, September 5.
6. Mature fruit, October 20.



acre in 1963 and only 19.5 grams per acre the following year. Field observations indicated a heavier crop of fruit had become established in 1964, but the loss from insect infestation was much higher in 1964 than in 1963. The total yield, yield per acre, and moisture content are presented in Tables 19 and 20. Parsley hawthorn production per plant was 10.9 grams in 1963 and 1.5 grams the following year. The other hawthorns produced 6.3 grams of fruit per plant in 1963 and only 0.4 gram in 1964. Higher yields for 1963 suggest that factors other than available moisture affected the fruit crop.

Regression analysis of yield was not attempted for hawthorn because of inadequate data. It became evident that lower tree basal areas generally resulted in higher yields of fruit when the yield by tree basal area classes were calculated (Table 21).

Determination of yield by tree canopy conditions revealed that hawthorns produced more consistent crops under a pine-hardwood multi- or midstory canopy (Table 22). The variation of yield between years was greatest when the canopy was absent or present as a midstory hardwood canopy. Above-average yields were obtained in 1963 when the canopy was absent or present as a midstory hardwood canopy, and in 1964 where the tree canopy was classified as an overstory of hardwoods, a multistory of pine-hardwood, or a midstory of pine-hardwoods. In general, there was very little correlation between years in the production of hawthorn fruit.

When the yield per acre was determined for each soil type, there was very little trend in production during this study. Table 23 reveals that the highest producing soils in 1963 produced a very small

Table 19. Parsley hawthorn fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	862.3	117.8	199.5	27.3
Dry weight, grams	337.1	45.1	78.0	10.5
Per cent moisture	60.9	61.7		

Table 20. Hawthorn fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	1,140.5	110.5	264.0	25.5
Dry weight, grams	517.4	39.1	119.8	9.0
Per cent moisture	54.6	64.6		

Table 21. Hawthorn fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year 1963	Year 1964
30 and below	1,224.3	45.3
40	0	0
50	1,486.5	79.0
60	57.5	18.3
70	20.8	10.0
80	27.3	20.3
90	14.8	0
100	0	14.5
110	80.5	144.0
120	--	--
130+	0	0
Average	188.5	19.5

Table 22, Hawthorn fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year 1963	Year 1964
Absent	727.5	3.5
Overstory		
Pine	7.5	0
Pine-hardwood	1.8	0
Hardwood	0	33.3
Multistory		
Pine	--	--
Pine-hardwood	97.0	42.5
Hardwood	5.8	21.8
Midstory		
Pine	--	--
Pine-hardwood	33.8	27.5
Hardwood	308.8	20.5
Average	188.5	19.5

Table 23. Hawthorn fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1-3	767.3	31.0
Beauregard	3-5	1,027.8	0
Bibb-Mantachie	0-1	0	0
Caddo	1-3	1.8	0
Cuthbert	1-3	14.0	6.0
Cuthbert	3-5	7.5	1.8
Cuthbert	5-20	8.0	48.0
Sawyer	1-3	577.5	143.3
Sawyer	3-5	---	---
Susquehanna	5-20	0	0
Local alluvial	0	519.0	0
Average		188.5	19.5

fruit crop in 1964. The Sawyer (1-3 per cent slope) was the only exception, as it was the third highest producer in 1963 and the highest in 1964. Three soils, Bibb-Mantachie (0-1 per cent slope), Sawyer (3-5 per cent slope), and Susquehanna (5-20 per cent slope), did not produce fruit either year. Fruit yields were above average on four soil types in 1963 compared to three in 1964. Beauregard (1-3 per cent slope) and Sawyer (1-3 per cent slope) soil types produced above-average yields both years.

Chemical content

The higher percentages of crude protein, phosphorus, potassium, and calcium in the parsley hawthorn fruit prompted the decision to treat it separately. Results of the chemical analyses are summarized in Tables 24 and 25. Parsley hawthorn means and standard deviations were obtained from five samples in 1963 and four in 1964. A comparison of the chemical analyses revealed that the parsley hawthorn fruit contained higher chemical content percentages than the other hawthorn fruit. Hawthorns, based upon ten samples in 1963 and four in 1964, were considerably lower in crude protein, phosphorus, and calcium than parsley hawthorn. For example, in 1963 the crude protein content of parsley hawthorn was 8.45 per cent compared to 3.36 per cent for the hawthorn group.

Means of the chemical analyses for all the parsley hawthorn samples were: crude protein, 7.83 per cent; phosphorus, .138 per cent; potassium, 1.14 per cent; and calcium, 1.58 per cent. For the other hawthorns, the chemical content means were: crude protein, 3.79 per cent; phosphorus, .089 per cent; potassium, 1.19 per cent; and calcium, .72 per cent.

Table 24. Proximate chemical content of parsley hawthorn fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	8.45	7.10	1.74	1.27
Phosphorus	.144	.132	.023	.031
Potassium	1.21	1.06	.09	.14
Calcium	1.47	1.66	.42	.53

Table 25. Proximate chemical content of hawthorn fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	3.36	4.22	0.97	1.33
Phosphorus	.072	.106	.015	.033
Potassium	1.06	1.32	.13	.21
Calcium	.63	.80	.16	.19

YAUPON

Plant description

Yaupon (_Ilex vomitoria_ Ait.) of the _Aquifoliaceae_ can usually be recognized in the field as a dense-crowned evergreen shrub or small tree with many short, stout stems. The range of yaupon extends from Texas east to Florida and north to Virginia, then west to Oklahoma.

The white flowers are very small and may be monecious, dioecious, or perfect. They occur on the branchlets of the previous year in nearly sessile clusters or as individuals. Fruits are translucent, bright red drupes which remain on the plant until late winter. The evergreen leaves are simple, alternate, and thick with a dark lustrous green upper surface and a paler lower surface. Usually, the leaves will vary greatly in size and shape on different plants.

Yaupon is a stiffly divergent plant with short, rigid, stout twigs and a smooth whitish-grey bark. It grows in open areas and as an understory plant under fully-stocked pine stands. A moist, well-drained soil provides the best site. Low sandy soils in woods or clearings produce a habitat in which yaupon can thrive.

The fruit is eaten by many non-game birds, bobwhite quail, turkey, deer, squirrels, and raccoons; and the foliage and twigs are readily browsed by deer and cattle. Yaupon is widely used as an ornamental because of its bright red fruit and evergreen leaves.

Flowering and fruiting

The flower buds, new leaves, and stem elongation indicated the growing season was well underway by April 10, and approximately two weeks later, the plants were in full bloom. Figures 15 and 16 present a pictorial development of flowers and fruit. By the first week of May, the new fruit crop had "set" and the young leaves were normal size. Growth of the immature fruit was rapid until it reached approximately mature size by mid-July. Yaupon fruit started maturing around mid-October, but it was mid-November before all the fruit had matured. Some fruit remained on the plants through December but was gone by mid-January.

Fruit yield

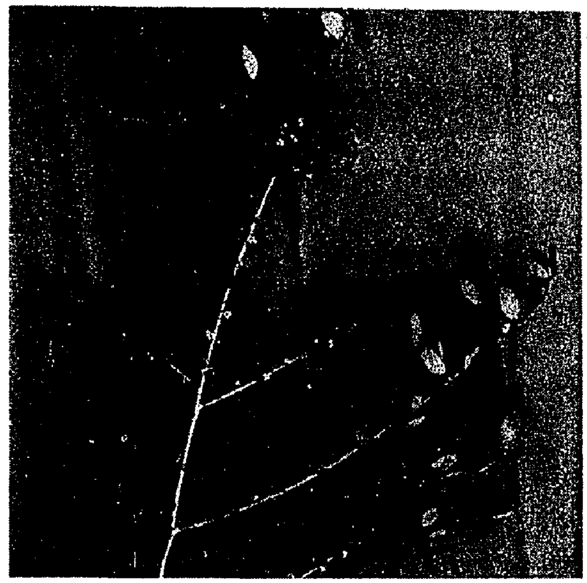
Of all plants that produced fruit during this investigation, the yield of yaupon was the lowest in 1963 and next to the lowest in 1964. The average yield of fruit in 1963 was only 14.8 grams per acre, and in 1964 it was 38.5 grams. Only ten plants were located on the study units and three of these produced fruit each year. Total yield, yield per acre, and per cent moisture of yaupon fruit are presented in Table 26. Average yield per plant was 6.36 grams in 1963 and 16.62 grams in 1964.

Table 26. Fruit yield of yaupon and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	136.2	385.8	31.5	89.3
Dry weight, grams	63.6	166.2	14.8	38.5
Per cent moisture	53.3	56.9		

Figure 15. Flower and fruit development of yaupon, 1964.

1. A fruit-bearing plant.
2. Stem showing flower buds, April 10.
3. Small flowers on stem, April 24.
4. New fruit crop, May 8.
5. Immature fruit, May 28.




4


5

Figure 16. Flower and fruit development of yaupon, 1964 (continued).

1. Immature fruit, June 15.

2. Immature fruit, July 3.

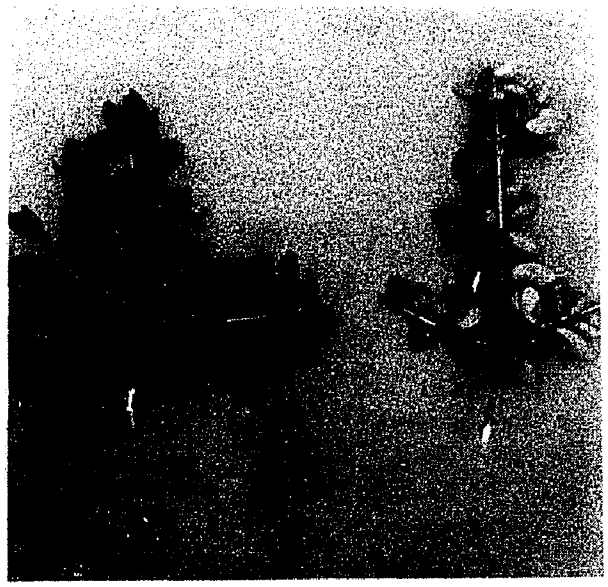
3. Immature fruit, July 17.

4. Immature fruit, August 17.

5. Immature fruit, September 5.

6. Mature fruit, October 20.

1



3

4

Data analyses by tree basal area, tree canopy condition, and soil type do not give a sound indication as to how these factors might affect fruit production because of the low plant density. Highest yields for both years were located in areas with a 50-square-foot tree basal area, as shown in Table 27. Yaupon produced fruit under only three basal area groups in 1963 and under two in 1964. Table 28 indicates the best yields were obtained when the tree canopy was absent or present as a pine overstory, as all fruit was produced under these two conditions. The yield by soil types indicated that the Cuthbert (3-5 per cent slope) was the most consistent producer, but additional information is needed before any conclusions can be drawn. Yield by soil types, shown in Table 29, revealed that only three soil types produced fruit during this study.

Chemical content

Chemical content means and standard deviations for 1963 and 1964 were based on three samples for each year and are presented in Table 30. Crude protein content was 1.77 per cent higher in 1963; which was the largest variation obtained in between-years comparisons of fruit chemical content. In all cases, 1963 fruit contained the higher chemical contents for all substances. The means of all samples obtained during this study were: crude protein, 6.155 per cent; phosphorus, .102 per cent; potassium, 1.245 per cent; and calcium, .235 per cent.

Table 27. Yaupon fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year	
	1963	1964
30 and below	--	--
40	29.8	0
50	119.8	398.8
60	--	--
70	--	--
80	0	0
90	14.3	16.5
100	--	--
110	--	--
120	--	--
130+	0	0
Average	14.8	38.5

Table 28. Yaupon fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	25.0	55.0
Overstory		
Pine	125.0	347.5
Pine-hardwood	0	0
Hardwood	--	--
Multistory		
Pine	--	--
Pine-hardwood	--	--
Hardwood	--	--
Midstory		
Pine	--	--
Pine-hardwood	--	--
Hardwood	0	0
Average	14.8	38.5

Table 29. Yaupon fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year 1963	Year 1964
Beauregard	1–3	0	0
Beauregard	3–5	--	--
Bibb-Mantachie	0–1	48.8	0
Caddo	1–3	0	0
Cuthbert	1–3	--	--
Cuthbert	3–5	38.0	126.5
Cuthbert	5–20	0	21.3
Sawyer	1–3	--	--
Sawyer	3–5	--	--
Susquehanna	5–20	--	--
Local alluvial	0	--	--
Average		14.8	38.5

Table 30. Proximate chemical content of yaupon fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	7.04	5.27	0.58	1.26
Phosphorus	.109	.094	.015	.014
Potassium	1.25	1.24	.09	.06
Calcium	.27	.20	.02	.12

MEXICAN PLUM

Plant description

Mexican plum (*Prunus mexicana* Wats.) of the *Rosaceae* is a small tree or shrub which grows to a height of 25 feet. The range includes the southcentral states as far north as Missouri, Tennessee, and Kentucky and south into northeastern Mexico.

Perfect white flowers, which are about one inch in diameter, appear before the leaves in few flowered umbels. The fruit, a drupe, is subglobose to short-oblong in shape, and when mature, it has a dark, purplish-red color with a bloom. Some of the fruit persist on the tree after it matures. The deciduous, simple, alternate leaves have serrate margins, sunken veins on the upper surface, and a yellowish, hairy lower surface with conspicuous veins.

Mexican plum is normally tree-like in its growth habits, and it does not produce root suckers. The crown is usually open and irregular in shape. Apparently, this plant grows best on well-drained, moist sites under fairly open forested conditions and is usually found as an understory plant in a pine or pine-hardwood forest. Mexican plum is classed as a drought-resistant plant.

The foliage and fruit are utilized by deer. In local areas, the fruit is gathered and used in making preserves and jellies. The roots have been used as grafting stock because of the species' drought-resistant nature.

Flowering and fruiting

Mexican plum was one of the earliest flowering plants, as evidenced by the fact that all the flowers had disappeared by April 10. Although it flowered heavily, only a small per cent of the flowers developed fruit. Insect infestation of the fruit was present by the first week of May, and fruit abscission soon followed. No fruit could be found by the end of May 1964. Picture number 5 of Figure 17 shows some of the insect-damaged fruit.

Based on observations made in 1963, the fruit continued to increase in size until it began to ripen by mid-August. Some of the fruit was mature by mid-September, and a few began to fall. All fruit had fallen by the first week of November, but some remained undamaged on the ground until the last week in January. Low rainfall during the fall of 1963 might have been responsible for undeteriorated fruit remaining on the ground for approximately two months.

Fruit yield

Mexican plum was the second highest fruit-producing species in 1963, but no fruit crop was produced the following year because of the insect infestation. During 1963, 1,721.2 grams of fruit were collected from the sample units. Fruit yield per acre was 398.3 grams, which, along with that of French mulberry, constituted more than 75 per cent of the fruit crop in 1963. Table 31 presents a summary of Mexican plum yield for 1963. Average crop per plant was 90.6 grams of fruit.

When the yield was analyzed according to tree basal area, tree canopy condition, and soil type, it became evident that the data obtained were insufficient to determine, with any accuracy, trends in

Figure 17. Flower and fruit development of Mexican plum, 1964.

1. Flowering plant, March 27.
2. Stem with flowers, March 27.
3. New fruit crop, April 10.
4. Immature fruit, compare with number of flowers in picture number 2, April 27.
5. Immature fruit showing worm infestation, May 8.

yield. The highest yield was obtained under a tree basal area of 80 square feet per acre, and the only other yield was produced under a 70 square-foot basal area timber stand. The highest yield, 1,869.0 grams per acre, was obtained when the tree canopy was absent. Fruit was also produced when the canopy was present as a pine-hardwood multistory and hardwood midstory. Tables 32 and 33 present average yields of fruit according to basal area and tree canopy conditions.

Table 31. Mexican plum fruit yield and moisture content

	Total	Per acre
	1963	1963
Field weight, grams	6,765.7	1,566.3
Dry weight, grams	1,721.1	398.3
Per cent moisture	74.6	

Two soil types produced fruit during this study (Table 34). Plants on the Beauregard (3-5 per cent slope) soil had a yield which averaged 11,639.8 grams of fruit per acre as compared to 376.3 grams from plants on the Cuthbert (3-5 per cent slope) soil. Evidently, these soils produced conditions suitable for fruiting when other factors, such as insect infestation, do not prevent a fruit crop on the plants.

Table 32. Mexican plum fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year
	1963
30 and below	--
40	--
50	0
60	0
70	29.0
80	2,288.5
90	0
100	0
110	0
120	0
130+	--
Average	398.3

Table 33. Mexican plum fruit yield by tree canopy conditions (Grams per acre)

Canopy condition	Year 1963
Absent	1,869.0
Overstory	
Pine	0
Pine-hardwood	0
Hardwood	--
Multistory	
Pine	--
Pine-hardwood	297.3
Hardwood	0
Midstory	
Pine	--
Pine-hardwood	--
Hardwood	28.3
Average	398.3

Table 34. Mexican plum fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year 1963
Beauregard	1-3	0
Beauregard	3-5	11,639.8
Bibb-Mantachie	0-1	--
Caddo	1-3	0
Cuthbert	1-3	0
Cuthbert	3-5	376.3
Cuthbert	5-20	0
Sawyer	1-3	0
Sawyer	3-5	--
Susquehanna	5-20	0
Local alluvial	0	--
Average		398.3

Chemical content

Chemical analyses of the three samples obtained from the fruit collections are summarized in Table 35. A wide variation in contents occurred even though the sample size was small. The chemical content means were: crude protein, 3.96 per cent; phosphorus, .078 per cent; potassium, 1.49 per cent; and calcium, 0.18 per cent. Data were not obtained on between-years variations because of the 1964 crop failure.

Table 35. Proximate chemical content of Mexican plum fruit in per cent of oven-dry weight

	Mean	Standard deviation
	1963	1963
Crude protein	3.96	0.91
Phosphorus	.078	.017
Potassium	1.49	.09
Calcium	.18	.02

BLUEBERRY

Plant description

Blueberries (*Vaccinium* spp.) of the *Ericaceae* occur throughout most of the eastern part of the United States. The identity of the species is not thoroughly understood because of the many hybrids that occur among species with overlapping ranges. Except for *Vaccinium aboreum*, all the species can be classified as shrubs because of their small size and branching habits.

The perfect flowers are usually white, light green, or rose and are generally somewhat bell-shaped with a drooping appearance. Blueberry fruit, a dark blue or black globose berry, has a persistent calyx on the terminal end. The simple leaves are alternate and usually vary greatly in size, even on the same plant. Blueberry leaves may be evergreen or deciduous, depending upon the plant species and the latitude at which it grows.

Blueberries grow best on acid soils and may be found in dense stands where the habitat is favorable. They are found on a wide variety of soil conditions, from moist stream bottoms to sandy ridges. Growth is usually best where full sunlight reaches the plant, but blueberry plants can exist under a forest canopy. Moist, well-drained sites are preferred by some of the species in this genus.

The fruit, which usually matures in the spring or summer, is eaten by many animals, including bears, opossums, raccoons, fox,rodents, and birds. Some species are cultivated by man for their fruit. The foliage varies from unpalatable to choice as a deer food, according to the species and the locality in which it grows.

Flowering and fruiting

There were several species of blueberries growing on the research area which bloomed at slightly different times. No attempt was made to identify the plants to species. By April 10, some of the blueberry plants had flowered and "set" fruit, while on others the flowering period was just starting. Fruit on the earlier flowering plants began to mature during the last week of April; whereas, other plants had only small fruit. During the last week of May, fruit on the early-flowering plants began maturing and had disappeared by mid-June. Fruit of the late flowering plants began maturing in June and had vanished before mid-July. See Figure 18 for an illustration of flower and fruit development.

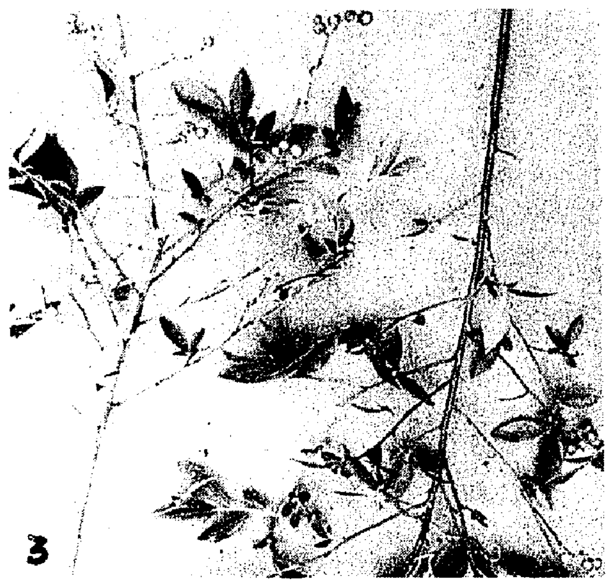
Blueberry fruit matures in the spring or early summer; therefore, it increases in size rapidly and begins to mature about the time it reaches normal size. This contrasts with the fall-maturing fruits which increase in size rapidly until approximately mature size is reached, then there is an inactive growth period until the fruit matures. Mature blueberry fruit normally does not remain on the plant.

Fruit yield

Blueberry fruits were collected only during the spring of 1964, as the 1963 crop was gone before this study was organized. The total yield from all units was 138.2 grams of fruit for an average production of 32.0 grams per acre. Total yield, yield per acre, and

Figure 18. Flower and fruit development of blueberry, 1964.

1. Flowering plant, April 10.
2. New fruit crop, April 24.
3. Immature fruit, May 8.
4. Immature fruit, May 28.
5. Maturing fruit, June 15.



3

4

5

moisture content are presented in Table 36. The average yield was exceeded by six other species in 1964, although it was the second most abundant plant.

Table 36. Blueberry fruit yield and moisture content

	Total	Per acre
	1964	1964
Field weight, grams	814.9	190.3
Dry weight, grams	138.2	32.0
Per cent moisture	83	

There was some fruit produced over a wide range of tree densities when the yields were grouped according to tree basal area conditions. Highest yield of 85.0 grams of fruit per acre was produced under a tree density equal to 70 square feet of basal area. Above-average yields were also obtained under tree basal areas of 60 and 130+ square feet. Seven out of 11 basal area conditions produced some blueberry yield (Table 37). According to the 1964 yield, the best production was obtained under a forest which had a basal area between 60 and 70 square feet.

Determination of yield by tree canopy conditions and soil types revealed a more definite trend of yields than when grouped on the basis of tree basal area (Tables 38 and 39). The highest yield,

Table 37. Blueberry fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year 1964
30 and below	0
40	26.8
50	0
60	33.3
70	85.0
80	0
90	29.3
100	5.8
110	0
120	17.0
130+	35.5
Average	32.0

Table 38. Blueberry fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year
	1964
Absent	5.3
Overstory	
Pine	57.8
Pine-hardwood	0
Hardwood	0
Multistory	
Pine	--
Pine-hardwood	8.8
Hardwood	18.0
Midstory	
Pine	--
Pine-hardwood	512.5
Hardwood	71.0
Average	32.0

Table 39. Blueberry fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year 1964
Beauregard	1-3	0
Beauregard	3-5	0
Bibb-Mantachie	0-1	32.3
Caddo	1-3	0
Cuthbert	1-3	0
Cuthbert	3-5	100.5
Cuthbert	5-20	4.8
Sawyer	1-3	16.5
Sawyer	3-5	0
Susquehanna	5-20	0
Local alluvial	0	0
Average		32.0

512.5 grams per acre, was obtained under a midstory pine-hardwood forest, and the second highest yield of 71.0 grams per acre was produced under a midstory hardwood forest. Above-average yields were also obtained under an overstory pine canopy, and only three other canopy conditions produced fruit. The Cuthbert (3-5 per cent slope) soil type produced an average crop of 100.5 grams per acre which was the highest yield by soil types. Plants on one other soil, the Bibb-Mantachie, had an above-average yield per unit. Four soil types out of 11 produced fruit in 1964.

<u>Chemical content</u>

Results of the chemical analyses, based upon 11 samples, are presented in Table 40. Variations in chemical contents of the oven-dry fruit were greater than normal when compared with the other plants. Phosphorus variation was the greatest because at least one of the samples had a percentage twice as great as that of the lowest. Crude protein, potassium, and calcium content variations were not quite as great.

Table 40. Proximate chemical content of blueberry fruit in per cent of oven-dry weight

	Mean	Standard deviation
	1964	1964
Crude protein	5.59	1.00
Phosphorus	.083	.031
Potassium	.68	.087
Calcium	.22	.041

TREE HUCKLEBERRY

Plant description

Tree huckleberry (*Vaccinium arboreum* Marsh) of the *Ericaeae* is a shrub or small tree that reaches a height of 30 feet. It is found throughout the southeastern and central states from Florida to Texas, north to Missouri, and east to Virginia.

The perfect, bell-shaped, white flowers are borne on short axillary racemes that have leaf-like bracts. The persistent berries, when mature, are globose, shiny-black, many-seeded, mealy, dry, and slightly sweet. Leaves, which vary greatly in size, are simple, alternate, and deciduous or persistent in the south. The leaves have entire to denticulate margins, and they are thick and leathery with a lustrous-green upper surface and a paler lower surface.

Tree huckleberry is an understory species found on moist soils near streams and lakes and along hillsides where the soil is moist and well-drained. This shrub is characterized by its crooked, stiff-branching habit. Unlike most members of this family, tree huckleberry does not require an acid soil condition for normal growth. It is absent from the flood plains of the larger rivers.

A number of birds and animals utilize the fruit of tree huckleberry, and the foliage is eaten by deer.

Flowering and fruiting

On April 10, flower buds, new leaves, and stem elongation were proof that the current growing season was well underway. Some of the flowers had opened by the last week of April, and flowers and small fruit were present when the area was visited two weeks later. Evidently, the new leaves had reached mature size. All the flowers were gone by May 24, and the new fruit crop was growing. Photographs showing flower and fruit development are presented in Figures 19 and 20. The fruit continued to increase in size from May 24 to August 1, then through August there was very little change in size. By September 5 some of the fruit had started maturing, but some green fruit was found until mid-October. Mature fruit was still present on December 24, but none could be found a month later. Some green leaves remained on the plants through the winter. Tree huckleberry was a consistent fruit producer during this study, but the fruit chemical contents were not very high.

Fruit yield

Total fruit collections in 1964 was almost double that of 1963. The total yield in 1963 was 352.4 grams of fruit, compared to 678.6 grams in 1964, and the moisture content of the fruit was slightly higher in 1964 (Table 41). The average fruit yield per acre was 81.5 grams in 1963 and 157.0 grams in 1964. Average production per plant in 1963 was 4.3 grams compared to 9.4 grams the following year. This was one of four study plants which produced a larger fruit crop in 1964 than in 1963.

Yields by basal area classes revealed evidence that tree basal area could have an effect on tree huckleberry fruit yield. Fruit was not produced after a tree basal area of 100 square feet or above was attained (Table 42). The best yield in 1963 was obtained under a

Figure 19. Flower and fruit development of tree huckleberry, 1964.

1. A fruit-bearing plant.

2. Branch showing small flower buds, April 10.

3. Flower buds almost open, April 24.

4. A flowering branch, May 8.

5. New fruit crop, May 28.

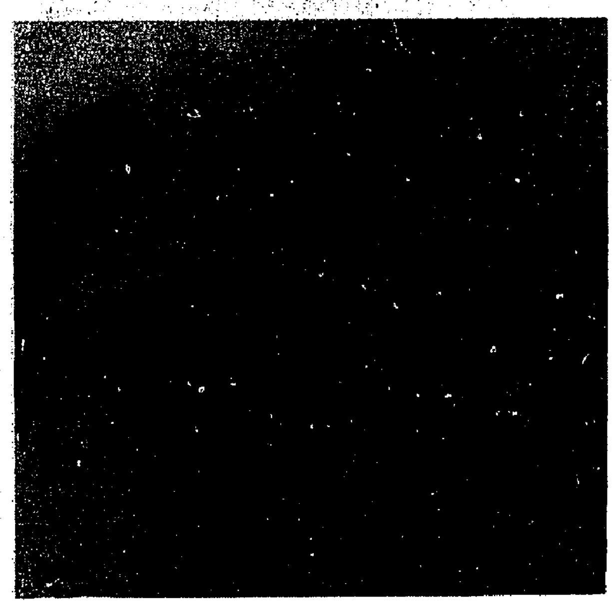


Figure 20. Flower and fruit development of tree huckleberry, 1964 (continued).

1. Immature fruit, June 15.
2. Immature fruit, July 3.
3. Immature fruit, July 17.
4. Immature fruit, August 17.
5. Immature fruit, September 5.
6. Mature fruit, October 20.


4
5
6

forest which had a 60 square-foot basal area, while the 1964 yield was best under a 50 square-foot basal area forest. Yields were obtained under all basal area classes, except 40, up to 100 square feet, but yields averaging better than 81.5 grams in 1963 and 157.0 grams in 1964 were obtained only twice in 1963 and once in 1964. The most consistent yields were obtained when the tree basal area was 30 square feet per acre or less. This yield was 166.3 grams in 1963 and 129.8 grams per acre in 1964. Four of the six basal area classes which produced some fruit both years had higher fruit yields the last year.

Table 41. Tree huckleberry fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	956.9	1,960.8	221.5	454.0
Dry weight, grams	352.4	678.6	81.5	157.0
Per cent moisture	63.3	65.4		

The yields were grouped according to tree canopy conditions in Table 43, and the highest yields were obtained under a midstory hardwood forest in 1963 and when the canopy was absent in 1964. All conditions except one that produced fruit in 1963 also had fruit in 1964. The best yield per acre of 422.8 grams in 1963 was better than twice that produced under the same canopy condition in 1964.

Table 42. Tree huckleberry fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year	
	1963	1964
30 and below	166.3	129.8
40	0	0
50	24.5	1,031.8
60	418.8	135.0
70	0.5	15.0
80	53.0	155.3
90	26.3	100.8
100	0	0
110	0	0
120	0	0
130+	0	0
Average	81.5	157.0

Table 43. Tree huckleberry fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	15.6	602.5
Overstory		
Pine	97.5	170.0
Pine-hardwood	0	119.3
Hardwood	4.5	308.3
Multistory		
Pine	--	--
Pine-hardwood	10.8	14.8
Hardwood	0.8	1.8
Midstory		
Pine	--	--
Pine-hardwood	--	--
Hardwood	422.8	165.5
Average	81.5	157.0

Above-average yields were obtained only once in 1963 and four times in 1964. The high yield of 1964, 602.5 grams per acre, was produced when the canopy was absent and the second highest yield was obtained under a hardwood overstory forest. Lowest yields for both years were obtained under a multistoried forest.

The fruit yield of tree huckleberry, based upon soil types, shows that a major part of the yield was produced on two soil types in 1963 and on three in 1964 (Table 44). Plants growing on local alluvial soils had the highest average yield both years. In 1963, the only other above-average yield was produced on the Cuthbert (1-3 per cent slope) soil. Plants on the Susquehanna soil type produced the second highest fruit yield in 1964 and was the only other soil type that had an above-average yield. Of the eleven soil types, five did not produce fruit either year.

Chemical content

Results of the chemical analyses were based upon 17 samples, six obtained in 1963 and eleven the following year. The chemical content means and standard deviations are shown in Table 45. Tree huckleberry fruit contained higher percentages of crude protein, phosphorus, and calcium in 1963 than in 1964, but the potassium content was slightly higher in 1964. As with the other study plant fruits, variation among samples within years was greater than between years. The means from 17 samples were 3.40 per cent crude protein, .061 per cent phosphorus, .67 per cent potassium, and .23 per cent calcium.

Table 44. Tree huckleberry fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1-3	3.8	32.8
Beauregard	3-5	--	--
Bibb-Mantachie	0-1	0	0
Caddo	1-3	0	0
Cuthbert	1-3	0.5	1.5
Cuthbert	3-5	213.0	100.0
Cuthbert	5-20	0	0
Sawyer	1-3	41.0	65.8
Sawyer	3-5	--	--
Susquehanna	5-20	0	253.0
Local alluvial	0	327.8	2,216.8
Average		81.5	157.0

Table 45. Proximate chemical content of tree huckleberry fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	3.59	3.20	1.11	0.54
Phosphorus	.062	.060	.022	.008
Potassium	.66	.68	.06	.07
Calcium	.24	.21	.09	.04

ARROWWOOD

Plant description

Arrowwood (*Viburnum dentatum* L.) of the *Caprifoliaceae* is a shrub which attains a height from three to fifteen feet. The range extends from eastern Texas to Florida and north to Massachusetts, which covers much of the eastern half of the United States.

The small, white, perfect flowers are located on 5-7 rayed terminal compound cymes which are located on lateral branches. The mature fruit, a drupe, is bluish-black in color, subglobose to ovoid in shape, and has a high oil content. The simple, opposite, deciduous leaves are usually thick and firm, especially on sun-exposed plants growing on dry sites. Veins extend to the dentate leaf margins. The leaves have sparsely pubescent to glabrous upper surfaces and sparsely to densely pubescent under surfaces.

Arrowwood may have one main stem or numerous stems originating from a clumped base. Wide variations in amount of pubescence and in size and shapes of leaves and cymes have resulted in the species being divided into a number of varieties by some authors. The twigs are slender, elongate, and usually straight or arching slightly. Arrowwood can be found growing naturally on many types of soils, but it is more common in moist, sandy areas along streams in upland forest lands.

The fruit of arrowwood is eaten by several species of birds and animals, including deer, which will also browse the foliage.

Flowering and fruiting

Arrowwood flower buds, located on current growth, were seen on the cymes by the first week of April. Flowers were present over an extended period as new blossoms were found through the last week in May along with some small fruit which had "set" by this time. Figures 21 and 22 present a pictorial development of the flowers and fruit of arrowwood. The fruit continued to increase in size until it reached approximate mature size by August 17. Maturing fruit was found the first week in September, and by October 20, all the fruit was mature.

An abscission layer began forming the latter part of November, and the fruit began falling by December 9, but some fruit was still found on the plants until December 24.

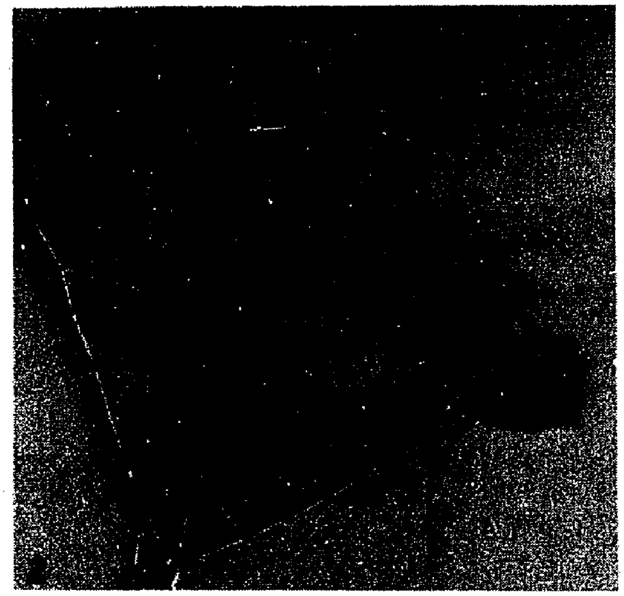
Fruit yield

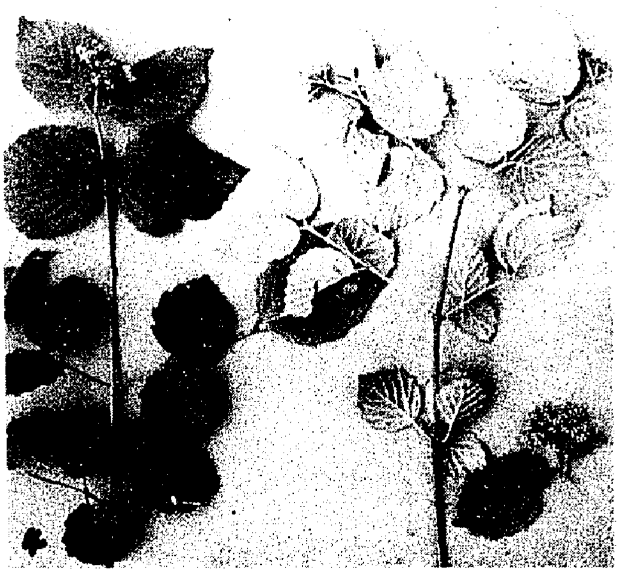
Arrowwood located on the study units produced twice as much fruit in 1963 as it did in 1964. The 1963 crop totaled 1,083.4 grams compared to 513.7 grams the following year. Each plant had an average fruit crop of 11.2 grams in 1963 and 5.3 grams in 1964. No obvious reason for this difference could be detected in the field. Table 46 presents the total collections of fruit for both years along with the average yield per acre and the moisture content. The average yield per acre was 261.0 grams in 1963 and 122.0 grams the following year.

When the yield was determined by tree basal area classes, it became evident that arrowwood produced fruit under a very wide range of tree basal areas. With one exception, fruit production in 1963 was higher where tree basal areas under 90 square feet per acre existed (Table 47). In 1964, plants on units with a basal area

Figure 21. Flower and fruit development of arrowwood, 1964.

1. Dormant plant, March 27.
2. Small terminal flower buds and new leaves, April 10.
3. Branch showing flower buds, April 24.
4. Flower buds and a few flowers, May 8.
5. Flowers and new fruit, May 28.





5

Figure 22. Flower and fruit development of arrowwood, 1964 (continued).

1. New fruit crop, June 15.
2. Immature fruit, July 3.
3. Immature fruit, July 17.
4. Immature fruit, August 17.
5. Mature fruit from plant in direct sunlight and immature fruit from shaded plant, September 5.
6. Mature fruit, October 20.


1
3
4
6

Table 46. Arrowwood fruit yield and moisture content

	Total		Per acre	
	1963	1964	1963	1964
Field weight, grams	2,372.2	1,099.8	549.0	254.5
Dry weight, grams	1,083.4	513.7	261.0	122.0
Per cent moisture	54.3	53.3		

Table 47. Arrowwood fruit yield by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year	
	1963	1964
30 or below	0	84.3
40	827.5	143.0
50	1,020.3	290.5
60	122.3	76.5
70	345.8	202.8
80	119.5	121.3
90	53.3	107.8
100	32.3	56.3
110	301.3	0
120	1.3	3.5
130+	94.0	33.0
Average	261.0	122.0

below 100 square feet produced the bulk of the fruit. Above-average fruit yields were obtained in four basal area classes in 1963 and 1964, and three of these classes were 40, 50, and 70 square feet.

The classification of yields by tree canopy conditions indicated that the best fruit crops occurred where the canopy was absent (Table 48). All conditions that produced fruit in 1963 also had a fruit crop in 1964. The only above-average yield per acre for 1963 was obtained in the absence of a canopy; whereas, in 1964 two tree canopy conditions, absent or present as a pine overstory, produced above-average crops. Generally, the lowest fruit yields were obtained under a pine-hardwood canopy.

Arrowwood fruit yields per acre by soil types are shown in Table 49. Plants on three soils had no fruit either year and those on a fourth had none in 1963. The highest yield per acre, 846.8 grams, was produced on the local alluvial soil in 1963. Above-average crops were obtained from the Cuthbert (3-5 and 5-20 per cent slope) soils during 1963. The Cuthbert (3-5 per cent slope) soil had the highest fruit yield in 1964 with two other soils, the Sawyer (3-5 per cent slope) and local alluvial, having above-average yields. The local alluvial and Cuthbert (3-5 per cent slope) produced more than one-half of the arrowwood fruit crop both years.

Chemical content

The chemical contents of arrowwood fruit were based upon 29 samples obtained in 1963 and 22 in 1964. Results of the analyses are presented in Table 50 which shows the means and standard deviations. Except for potassium, the percentages were higher in 1963.

Table 48. Arrowwood fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	1,115.0	279.5
Overstory		
Pine	82.5	250.0
Pine-hardwood	45.8	75.0
Hardwood	100.0	15.3
Multistory		
Pine	--	--
Pine-hardwood	67.3	89.5
Hardwood	257.5	100.3
Midstory		
Pine	--	--
Pine-hardwood	--	--
Hardwood	99.0	42.8
Average	261.0	122.0

Table 49. Arrowwood fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1-3	0	3.3
Beauregard	3-5	0	0
Bibb-Mantachie	0-1	0	0
Caddo	1-3	43.3	45.3
Cuthbert	1-3	37.3	47.3
Cuthbert	3-5	576.0	293.8
Cuthbert	5-20	314.5	12.3
Sawyer	1-3	101.3	53.5
Sawyer	3-5	98.5	425.0
Susquehanna	5-20	--	--
Local alluvial	0	846.8	269.5
Average		261.0	122.0

Table 50. Proximate chemical content of arrowwood fruit in per cent of oven-dry weight

	Mean		Standard deviation	
	1963	1964	1963	1964
Crude protein	6.47	6.28	0.63	0.59
Phosphorus	.146	.132	.029	.020
Potassium	1.47	1.48	.18	.13
Calcium	.48	.44	.16	.12

Means of the 51 sample analyses, given as per cent of oven-dry weight, were as follows: crude protein, 6.380; phosphorus, .139; potassium, 1.475; and calcium, .460. The chemical analyses indicated that arrowwood fruit was above normal in food value when compared to the other plant fruits.

MUSCADINE

Plant description

Muscadine (Vitis rotundifolia Michx.) of the Vitaceae can be found growing throughout most of the Gulf and Atlantic Coastal Plain from eastern Texas to Washington, D. C. and west to Missouri and Kansas.

The polygamo-dioecious flowers are borne in dense, short-branched panicles. The staminate panicles are larger than the pistillate, which sometimes bears a tendril branch. Muscadine fruit, a subglobose, purplish-black berry, drops as soon as it matures. The skin and flesh of the fruit are tough, but the flesh is edible. The leaves are alternate, simple, and deciduous with a coarsely angular-dentate margin. They have a glabrous, dark green upper surface and a lighter lower surface.

Muscadine grape is a slender, high-climbing vine with a tight bark that does not shred as other grapes. Heights up to 100 feet have been reached by this vine. The tendrils are simple and are absent from every third node. The vine will produce aerial roots at times.

The muscadine fruits are eaten by many birds and animals. Raccoons, squirrels, and opossums utilize the flesh and seed of the fruit. The foliage of muscadine is known to be browsed by deer.

Flowering and fruiting

Small leaves and new stems were the only visible signs of growth the first week of April. Catkins or panicles could be identified by mid-April and were still present two weeks later. Fruit had "set" by the last week in May and grew rapidly until about mid-July. Photographs of the developing catkins and fruit of muscadine are presented in Figure 23. Some of the insect-damaged fruit began maturing prematurely from mid-July through mid-August, when the undamaged fruit began turning from green to purplish-black. By September 1, 1964, no fruit could be found around the study area. It was assummed that the entire crop was consumed by birds, raccoons, opossums, and squirrels.

Fruit yield

Only two of the 42 muscadines inventoried on the study units produced fruit in 1963, and the 1964 crop was consumed by animals before collections were attempted. Combined weight of the two samples was only 17.5 grams, or an average yield of 4.1 grams per acre in 1963, the lowest fruit-producing plant included in the study. The field weight of the fruit collected was 102.5 grams, and the moisture content was 82.9 per cent. No attempt was made to analyze the fruit according to tree basal area, tree canopy condition, or soil type.

Chemical content

Chemical analyses of the two samples were made with the following results: per cent of crude protein was 4.19 and 5.38 with a mean of 4.79, phosphorus content was .097 and .105 with a mean of .101 per cent, potassium content was 1.12 and 1.23 with a mean of 1.18 per cent, and calcium content was .49 and .78 with a mean of .64 per cent.

Figure 23. Catkin and fruit development of muscadine, 1964.

1. Vine with small catkins, April 24.

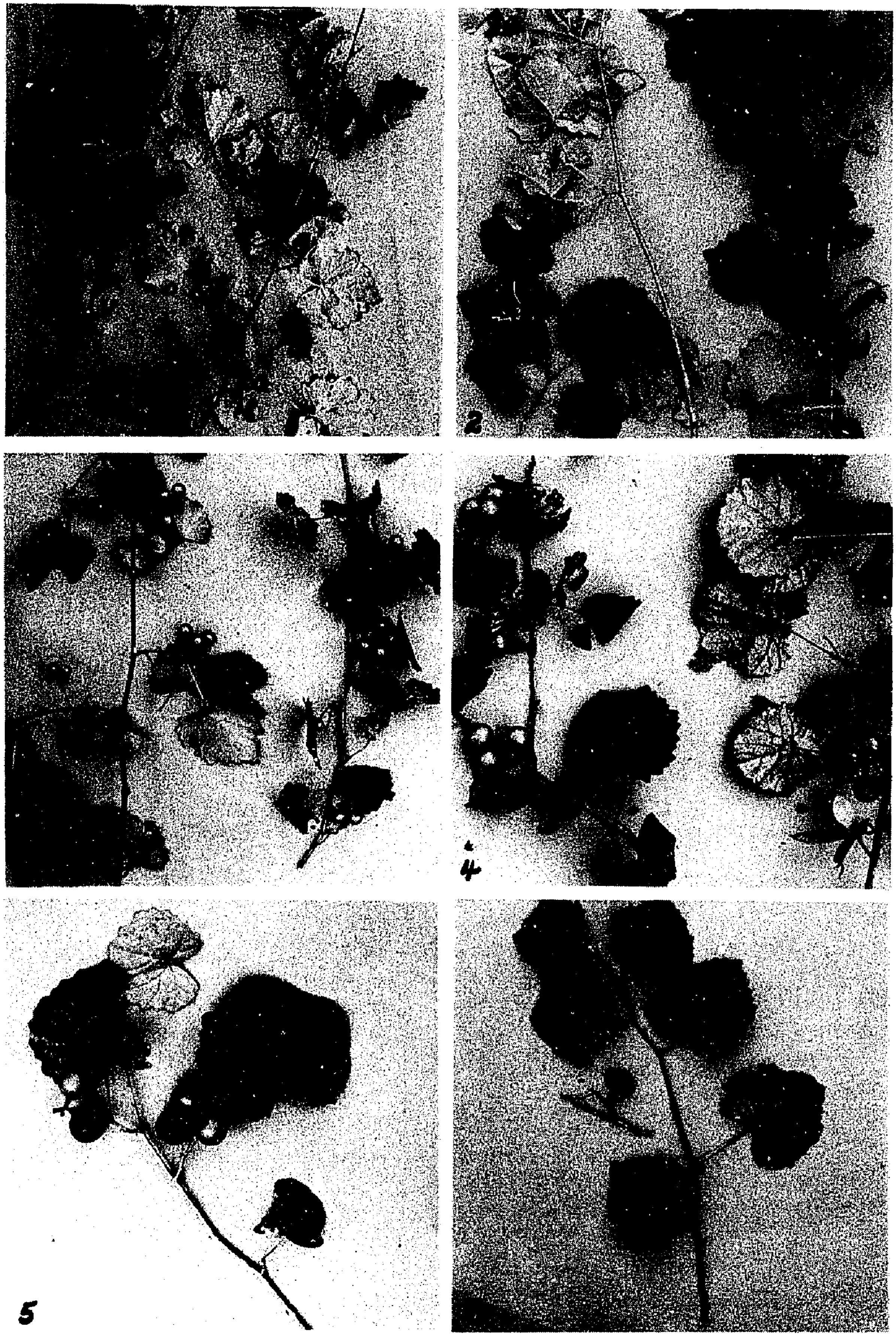
2. Vine with new fruit crop, May 8.

3. Immature fruit, June 15.

4. Immature fruit, July 17.

5. Maturing fruit, August 17.

6. Mature fruit, September 5.


2
4
5

BLACKBERRY

Plant description

Blackberry (Rubus spp.) of the Rosaceae is a very difficult group to classify taxonomically because of the many hybrids which occur when the ranges of different species overlap. Many cultivated varieties have escaped to make the classification even more complicated. The genus is found throughout most of the Northern Hemisphere.

The flowers are usually perfect and white or rarely reddish in color. Blackberry fruit, small drupelets on a fleshy receptacle, are black or blackish when mature. The receptacle, which becomes soft and juicy, usually remains intact with the drupelets. The leaves, digitately 3-7 foliolate, are alternate and deciduous with both surfaces being approximately the same shade of green.

Blackberries are perennial herbs or more often somewhat shrub-like and woody. The stems or canes are armed with prickles or bristles, and they often grow to a height of eight feet in dense thickets. The woody canes often persist for several years. Blackberries can be found growing on almost any habitat that permits sufficient light penetration. Best growth is on open areas such as cleared land, abandoned fields, or cut-over forest land.

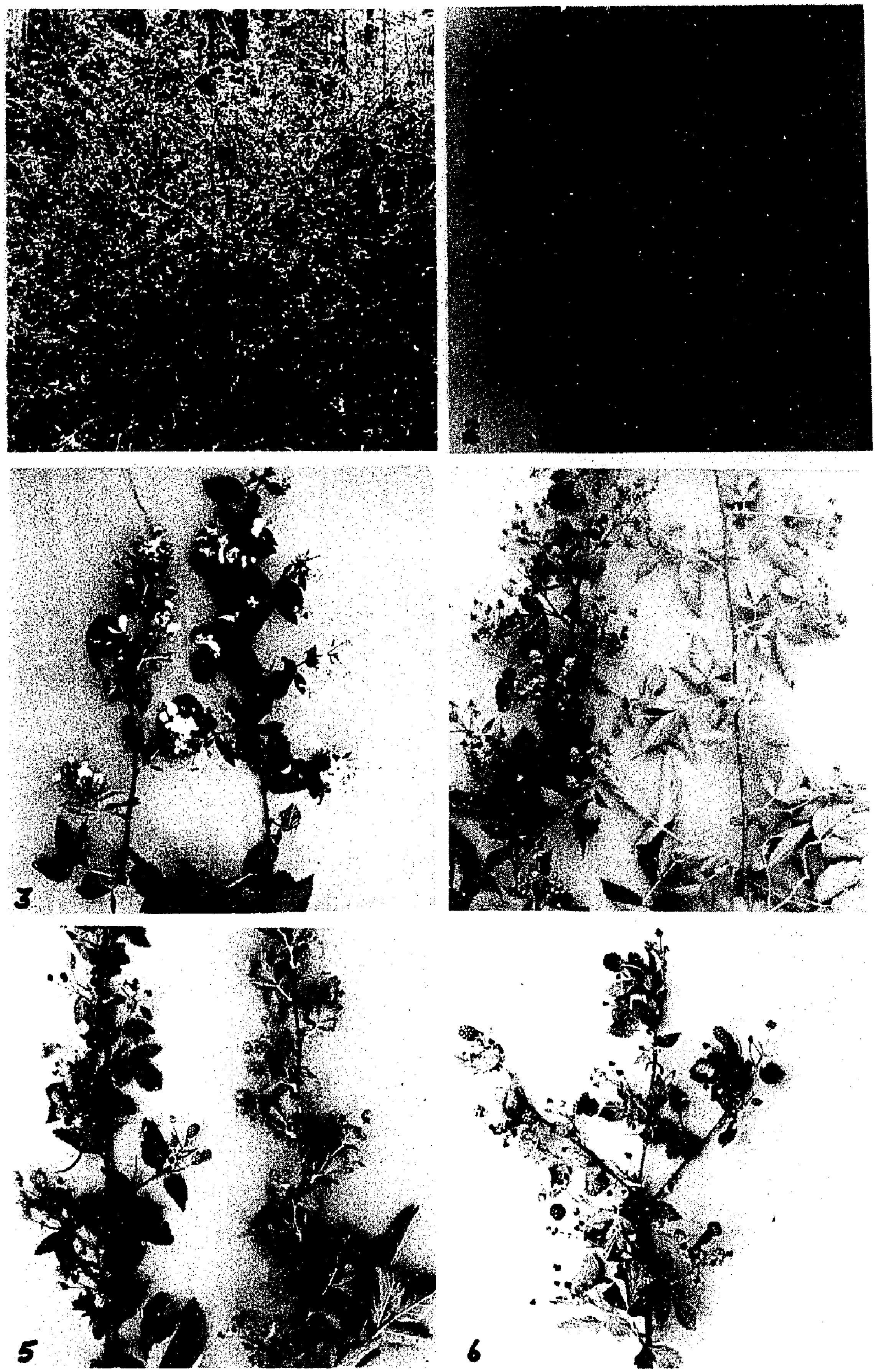
Blackberries provide food and cover for many of our wild animals. The fruit is eaten by many game and non-game birds, deer, raccoon, opossum, fox, and other animals. The succulent stems and leaves are important as a deer food. Both wild and domestic fruits are gathered to make preserves, jellies, wines, etc.

Flowering and fruiting

When the area was visited on April 10, new leaves, current stem growth, and partly opened flowers were found on blackberry plants near the study area, and these plants were used in studying flowering and fruiting habits. Two weeks later the flowers were open and the leaves were still growing. Small fruits were present on May 8, and the leaves were about normal size. By the last week of May, some of the fruits were turning from green to red and by mid-June many were mature. A month later no fruit could be found. See Figure 24 for pictures of the flower and fruit development. Since the blackberry plants on the study units produced no fruit, the fruit yield of this plant could not be determined. No chemical analysis was made.

Figure 24. Flower and fruit development of blackberry, 1964.

1. Blackberry canes or stems, March 27.
2. Flower buds on cane, April 10.
3. Flowering cane, April 28.
4. New fruit crop, May 8.
5. Immature fruit, May 28.
6. Maturing and mature fruit, June 15.


3
5
6

RUSTY BLACKHAW

Plant description

Rusty blackhaw (Viburnum rufidulum Raf.) of the Caprifoliaceae is a large shrub or small tree with a natural range that extends from eastern Texas to Florida and northward to Virginia and west to Kansas.

The perfect flowers are white and form flat cymes up to six inches in diameter. Rusty blackhaw fruit forms drooping clusters of bluish-black, obovoid to oblong drupes. The leaves are simple, opposite, and deciduous or half-evergreen in the southern part of its range. Margins of the leaves are finely serrate. Upper surfaces of the leaves are a shiny dark green while the lower surfaces are paler with red hairs on the veins.

Rusty blackhaw grows as a under-story plant on many sites from river bottomlands to dry upland soils. It will grow best on moist, rich alluvial soil. Total height of the plant is seldom over 25 feet. The almost black, alligator-type bark, hairy buds, and stiff stems are primary identification marks.

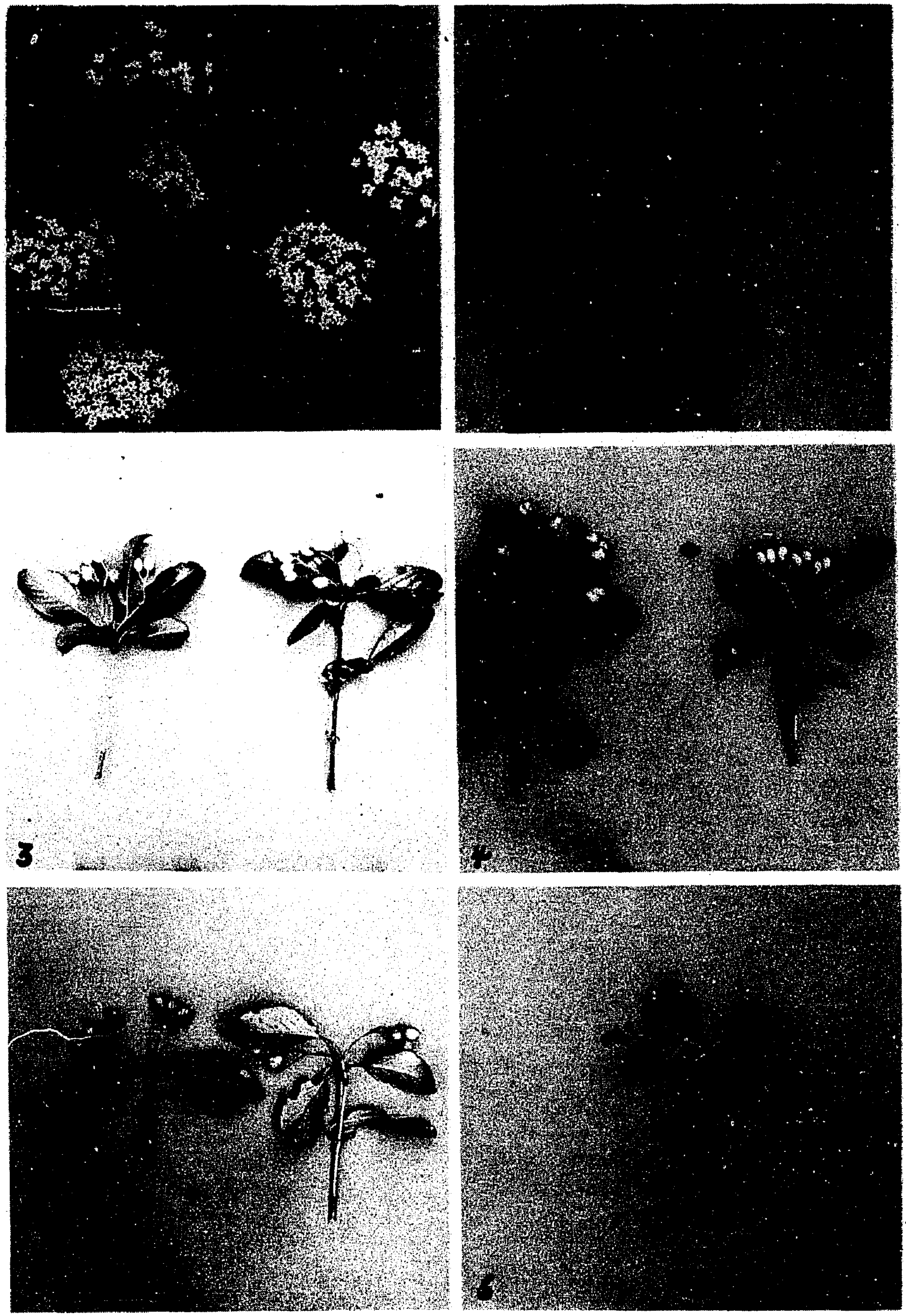
The fruits are eaten by birds and mammals. Rusty blackhaw foliage is of some value as a deer browse.

Flowering and fruiting

Two flowering rusty blackhaws, with new leaves and current shoot growth, were found outside the study area on April 10, 1964. Two weeks later some fruit had "set" and was increasing in size; however, many flowers did not produce fruit. From May 8 to July 17, the fruit increased in size rapidly and had reached approximately mature size by August 1. Photographs of the developing flowers and fruit are presented in Figure 25. By mid-August some of the fruit on the two plants began to mature but was not all mature until October. Yield and chemical content data were not obtained on rusty blackhaw fruit since plants on the study units had no fruit crop either year.

Figure 25. Flower and fruit development of rusty blackhaw, 1964.

1. Flowering branch, April 10.
2. New fruit crop, April 24.
3. Immature fruit, compare with number of flowers in picture number 1, June 15.
4. Immature fruit, July 17.
5. Immature fruit, September 5.
6. Mature fruit, October 20.



COMBINED FRUIT YIELDS

Total yield

The total fruit production of the selected deer-browse plants can be presented by consolidating the yields from all plants. The combined units had an area of 4320 milacres or 4.32 acres. During 1963, 8,675.6 grams of fruit were collected compared to 14,849.5 grams the following year. Only four plants, French mulberry, dogwood, yaupon, and tree huckleberry had higher yields in 1964, the year with the more normal amount of rainfall. Fruit yield variations were great from one year to the next.

With all species, except arrowwood, the moisture content was greatest in 1964. The percentage of moisture in 1963 varied from 46.3 for dogwood fruit to 82.9 for muscadine fruit. The following year, dogwood fruit again had the lowest moisture content and blueberry fruit contained the highest amount. For both years, except for dogwood in 1963, the fruit moisture content was greater than 50 per cent.

Table 51 presents fruit yields per acre for both years. These yields were determined each year for all plants that had fruit. The highest total yield, 3,427.4 grams per acre, occurred in 1964. The yield per acre in 1963 was 2,008.2 grams. French mulberry had the highest yield both years and produced the bulk of the crop in 1964. The second highest producing species were Mexican plum in 1963 and

Table 51. Fruit yield in grams per acre and moisture content

	Field weight		Dry weight		Per cent moisture	
Species	1963	1964	1963	1964	1963	1964
French-mulberry	3,675.0	14,175.0	832.5	2,590.0	77.3	81.7
Dogwood	425.0	987.5	227.3	482.3	46.3	51.3
Parsley hawthorn	199.5	27.3	78.0	10.5	60.9	61.7
Hawthorn	264.0	25.5	119.8	9.0	54.6	64.6
Yaupon	31.5	89.3	14.8	38.5	53.3	56.9
Mexican plum	1,566.3	0	398.3	0	74.6	0
Blueberry	—	190.3	—	32.0	—	83.0
Tree huckleberry	221.5	454.0	81.5	157.0	63.2	65.4
Arrowwood	549.0	254.5	261.0	122.0	54.3	53.3
Muscadine	23.7	0	4.0	0	82.9	0
Blackberry	0	0	0	0	0	0
Rusty blackhaw	0	0	0	0	0	0
Total	6,955.5	16,203.1	2,017.2	3,441.3		

dogwood in 1964. Arrowwood ranked third in fruit production in 1963, but tree huckleberry held third position the next year.

Yield by tree basal area classes

The entire study area was used in determining the total yield for each basal area class; therefore, the consolidation of these individual yields should present the overall effect of tree density on yield of understory plant fruit (Table 52). Maximum fruit production was attained in 1963 when the tree basal area was 30 square feet or less. Yield per acre from plants in basal area class of 80 square feet was unusually high because more than 90 per cent of the Mexican plum fruit were produced under this condition. The highest yields in 1964 were attained when a tree basal area of 40 square feet was present. If the high yield from 80-square-foot units were disregarded, it seems that competition for soil moisture began between basal areas 50 and 60, where a sharp drop in fruit yield occurred in 1963. Except for the large drop at the 50-square-foot level due to above-average yields at the 40-square-foot level, production declined slowly but steadily as per-acre basal areas increased. An examination of yields in basal area classes 90 through 130+ indicates the effect of plant competition on the fruit yield of understory plants included in this study. The yield in this area was over three times greater in 1964 than in 1963.

Better-than-average yields were maintained in 1963 until the tree basal area was greater than 60 square feet, except in the 80-square-foot class. In 1964, above-average yields were produced until a tree basal area of 80 square feet occurred. French mulberry and arrowwood

Table 52. Total fruit yields by tree basal area classes

(Grams per acre)

Basal area in sq. ft. per acre	Year	
	1963	1964
30 or below	5,189.0	4,865.4
40	3,582.1	8,312.3
50	3,611.1	4,187.1
60	1,766.0	3,618.8
70	1,686.4	3,290.8
80	3,669.6	3,443.2
90	1,081.4	3,447.1
100	252.3	2,170.6
110	589.3	1,746.5
120	106.3	1,135.5
130+	229.0	960.0
Average	2,017.2	3,441.3

produced fruit over the widest range of basal area classes.

Tree basal area values were used as an independent variable in all multiple regression analyses, which indicated that fruit yields decreased as basal areas increased. Results of a linear regression analysis to determine the relationship between fruit yield ($\hat{Y}$) and tree basal area are presented in Figures 26 and 27. A definite relationship existed as indicated by significant t-test at the 0.05 level, but the r^2 values show that only a small percentage of the variation is accounted for.

Yield by tree canopy condition

A visual determination of the tree canopy was used as a means of indicating the amount of direct sunlight striking the understory plants. This should have determined indirectly the correlation between fruit yield and light, as visual estimates are not always consistent. Average yields of the plants, when classified according to tree canopy conditions, are presented in Table 53. Only one unit was located in a mixedstory pine forest and none in a forest which could be classed as having a midstory pine canopy. The yield data analyses indicated that tree canopy condition has an appreciable effect on fruit yield of understory plants.

Most consistent and highest yields for the two year period occurred in the absence of an overhead tree canopy. Fruit production in the absence of a canopy was 6,939.6 grams per acre in 1963 and 7,580.3 grams the next year. Yields where the overhead canopy was absent or present as a midstory hardwood canopy varied little between years. Under all other conditions, the between-year variation was

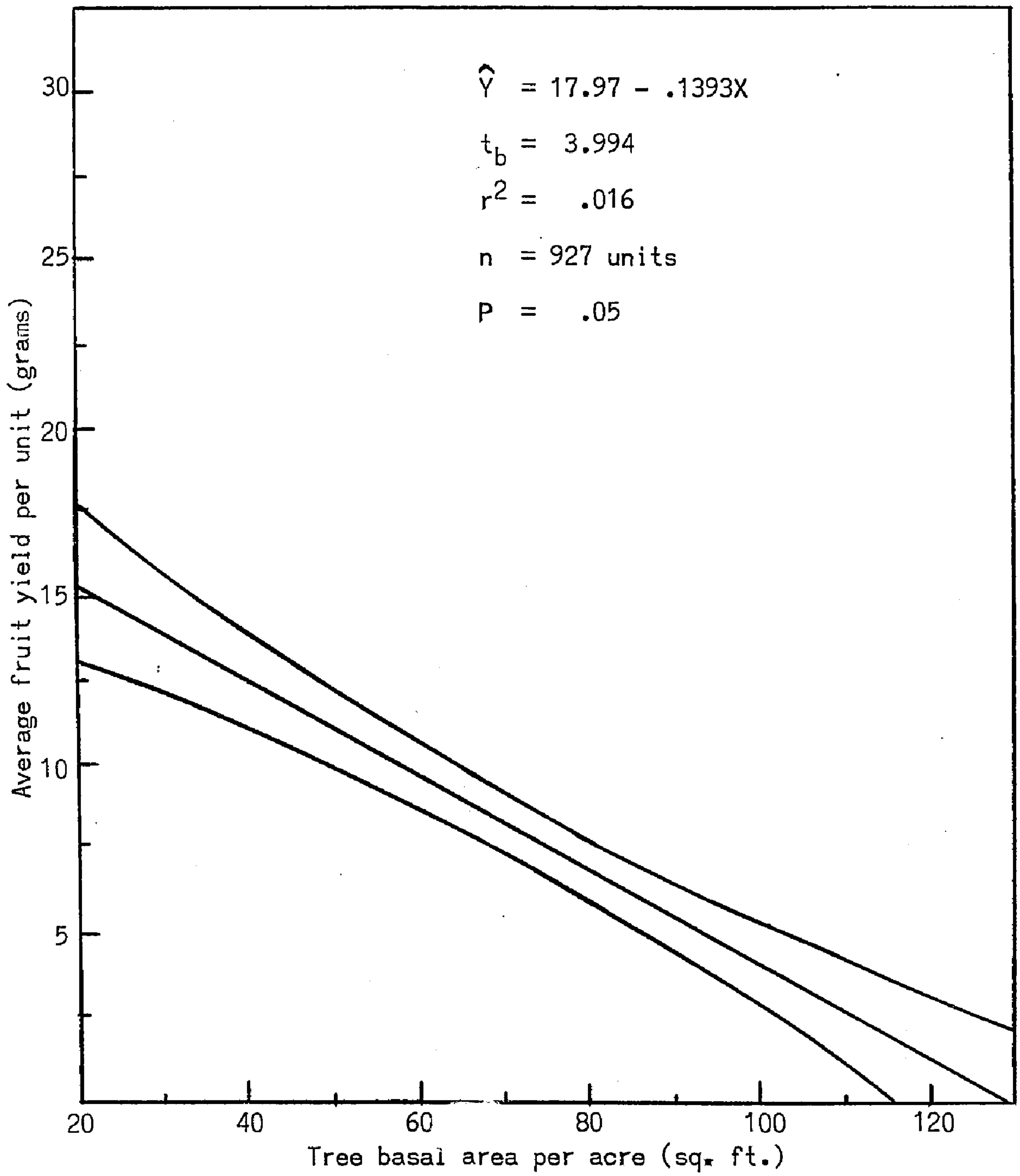


Figure 26. Combined fruit yield/basal area relationship, 1963, with confidence limits at the 5 per cent level.

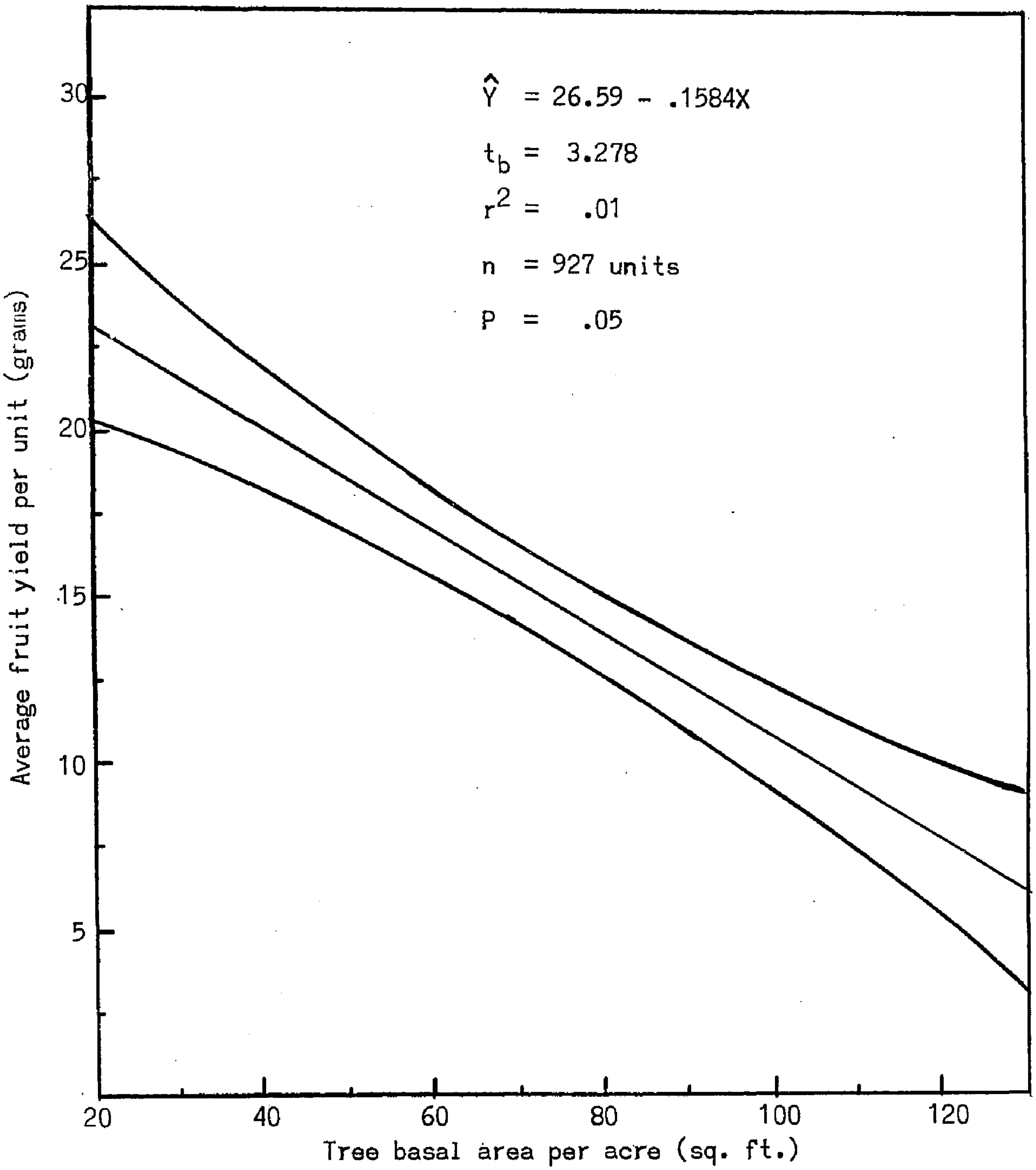


Figure 27. Combined fruit yield/basal area relationship, 1964, with confidence limits at the 5 per cent level.

Table 53. Total fruit yield by tree canopy conditions

(Grams per acre)

Canopy condition	Year	
	1963	1964
Absent	6,939.6	7,580.3
Overstory		
Pine	1,950.0	7,310.1
Pine-hardwood	766.8	3,946.6
Hardwood	3,680.0	5,687.5
Multistory		
Pine	--	--
Pine-hardwood	892.9	1,844.6
Hardwood	541.1	1,326.9
Midstory		
Pine	--	--
Pine-hardwood	708.8	3,148.8
Hardwood	1,501.0	2,048.0
Average	2,017.3	3,441.3

much greater. Fruit production in 1964 was greater under all canopy conditions. Variations in yield between years were greatest when the tree canopy was classed as a pine-hardwood overstory or as a pine-hardwood midstory. Consolidated yields also indicated that fruit production was less under a mixed-hardwood canopy than under any other condition. When the tree densities are similar, there would be less light penetration under this type of canopy than any other.

Next to highest yields in 1963 were obtained under a hardwood overstory canopy. The second highest yield in 1964 occurred under a pine overstory, and fruit yield under a hardwood overstory canopy was third in 1964. Above-average yields were obtained under two conditions in 1963 and four times in 1964. In all cases, the above-average yields were obtained when the canopy was absent or present as an overstory.

Only two study plants, dogwood and yaupon, produced their highest yield both years when a canopy was present. Dogwood fruit crops were best under a hardwood overstory canopy, and yaupon fruit production was best under a pine overstory canopy. Over 80 per cent of the fruit crop was produced when the canopy was absent or present as an overstory. The effect of a midstory canopy condition on fruit production of understory plants can be clearly seen here.

Data cards for the statistical analyses were processed through the computer by grouping according to tree canopy conditions regardless of plant species. Results of the analyses are presented in Table 54. As indicated in the table, the R^2 values of the expected yield formulas ranged from .01 to .91. In seven out of eight conditions for which formulas were obtained, the highest R^2 values were obtained in the

Table 54. Expected yield formulas by tree canopy conditions

Canopy condition	Year	Number Samples	B_0	X_1	X_2	X_3	X_4	X_5	R^2
Absent	1963	162	106.41	-2.25	- 1.24	- .20	- .71	38.90**	.07
	1964	162	381.46	- .61	4.43	- .01	- 7.50	-19.2	.01
Overstory Pine	1963	90	6.39	0.79	16.97**	-1.59**	- 5.36	0.96	.32
	1964	90	348.31	-1.90	54.20**	-10.87**	28.62	66.22	.12
Pine-hardwood	1963	63	11.38	-1.55	3.01	÷0.33	0.21	5.91	.12
	1964	63	262.01	-2.03	- 3.60	0.51	- 3.96	16.04	.05
Hardwood	1963	30	182.53	1.26	99.99**	-5.54	- 2.22**	-92.62**	.91
	1964	30	191.27	2.58	77.33**	-4.36	15.93	-92.00	.81
Mixedstory Pine-hardwood	1963	318	57.01	-0.90	7.91**	0.46	- 0.18	- 4.55	.07
	1964	318	144.25	-0.83	5.12**	-0.18	- 1.82	0.97	.03
Hardwood	1963	98	-117.17	-0.14	1.56	-0.58	6.25	14.26	.08
	1964	98	142.18	-0.67	14.17**	-1.63**	11.74	- 4.29	.22
Midstory Pine-hardwood	1963	17	50.07	-0.13	6.18	0.02	- 1.34	- 8.28	.17
	1964	17	189.10	0.76	5.10	0.18	- 1.78	-35.17	.17

Table 54. (continued) Expected yield formulas by tree canopy conditions

Canopy condition	Year	Number Samples	B_0	X_1	X_2	X_3	X_4	X_5	R^2
Hardwood	1963	149	19.15	-0.70	7.56	-0.21	- 2.61	14.05	.09
	1964	149	136.64	-0.16	-2.11	- .14	- 1.35	- 0.96	.03

** t-test significant at P = .05

analyses of the 1963 fruit crop. The best prediction equations were obtained when the canopy was present as a hardwood overstory. Results of the statistical analyses are not consistent enough to draw any definite conclusions, except to state that factors other than those included as independent variables have an effect on the fruit production of the study plants.

Yield by soil types

According to the soils map, there were 13 soil types located within the study area, but no units were located within the Bowie type and only one in the Susquehanna (1-5 per cent slope) type. The number of units occurring within the other soil types varied from 18 to 309. No distinction was made as to closure units when analyzing the yield data according to soil type. All units were used in calculating the average yields per acre in each soil type and the results of the analyses of fruit yield by soil types are presented in Table 55. Fruit production was higher on all soil types in 1964.

Although the yields were different for the two years, the same two soils produced the highest fruit yields both years. In 1963, the largest crop was produced on the Beauregard (3-5 per cent slope) soil type while the best producing soil for 1964 was the local alluvial soil. Yields per acre by soil type varied from 290.0 grams to 15,215.1 grams in 1963 with a mean yield of 2,017.3 grams per acre. For 1964, the mean yield was 3,441.3 grams per acre with a variation from 1,109.8 to 7,461.6 grams.

More units were located on the Cuthbert (3-5 per cent slope) soil type than any other, and this soil also had the greatest variety of

Table 55. Total fruit yield by soil types

(Grams per acre)

Soil type	Per cent slope	Year	
		1963	1964
Beauregard	1-3	1,549.1	3,389.6
Beauregard	3-5	15,215.1	4,985.0
Bibb-Mantachie	0-5	728.0	1,109.8
Caddo	1-3	2,074.1	3,201.6
Cuthbert	1-3	1,813.8	4,175.1
Cuthbert	3-5	1,946.6	2,973.1
Cuthbert	5-20	1,773.3	3,080.9
Sawyer	1-3	1,027.8	3,527.6
Sawyer	3-5	290.0	3,079.0
Susquehanna	5-20	412.3	1,174.5
Local alluvial	0	2,448.1	7,461.6
Average		2,017.3	3,441.3

study plants producing fruit. In 1963, it ranked fourth in yield per acre, but in 1964 its position dropped to ninth. The Sawyer soil's fruit yields varied the greatest between years, while Bibb-Mantachie (0-5 per cent slope) had the smallest between-year variation.

Results of the multiple regression analyses are presented in Table 56. The expected yield equations obtained from the analyses cannot be used to accurately predict fruit yield because of the small R^2 values. The R^2 values, which varied from .03 to .63, indicate that factors other than the independent variables included in the analyses affect the production of fruit. Generally, the R^2 values were smaller for 1964 than 1963, which possibly indicate the effect of rainfall differences.

Chemical content

Complete chemical analyses of the fruits produced by the study plants can be seen in Table 57. Crude protein, phosphorus, potassium, and calcium percentages were obtained by determining the means of individual samples. Fruit analysis results from both years were combined in order to obtain the crude protein, phosphorus, potassium, and calcium means. Magnesium, iron, zinc, fat, fiber, and ash percentages were determined from a composite sample of each species.

According to the chemical analyses, parsley hawthorn and arrowwood fruit had the highest content of crude protein and phosphorus, and tree huckleberry had the lowest content. The highest percentage of potassium was obtained in Mexican plum and arrowwood fruit. Calcium content percentages varied from 0.180 to 1.600, with dogwood fruit containing the highest percentage. Yaupon fruit contained the

Table 56. Expected yield formulas by soil types

Soil type	Slope %	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
Beauregard	1-3	118	1963	157.3	-1.72**	15.23**	-1.78	32.04**	- 7.27	.19
		118	1964	324.8	-1.49	- 8.43	- .63	-10.91	13.58	.09
Beauregard	3-5	21	1963	- 85.44	-3.06	-17.41**	.44**	40.07	88.66**	.62
		21	1964	- 73.03	2.51	-11.39	1.97	48.26	-23.13	.08
Bibb-Mantachie	0-5	24	1963	25.54	- .50	3.21	-5.65	79.60	35.94	.30
		24	1964	114.35	- .64	- .11	-3.94	36.5	31.0	.22
Caddo	1-3	70	1963	373.5	-2.31**	11.28	-2.21	50.52	-35.32	.15
		70	1964	442.2	-2.53**	4.62	-1.07	16.14	-20.80	.11
Cuthbert	1-3	162	1963	232.09	-1.89**	6.19	- .17	- .57	- 7.65	.06
		162	1964	300.29	- .79	12.78**	- .29	- 2.84	-20.53	.04
Cuthbert	3-5	291	1963	49.00	-1.04	6.71	- .11	- 2.38	14.40	.05
		291	1964	218.48	-1.22	.33	- .43	- 1.32	3.44	.03
Cuthbert	5-20	82	1963	- 49.06	- .29	44.97**	3.80	-69.98**	-34.58	.57
		82	1964	8.49	- .72	27.79**	4.02	-56.87	-13.16	.42

Table 56. (continued) Expected yield formulas by soil types

Soil type	Slope %	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
Sawyer	1-3	87	1963	-147.65	1.32	-22.42	4.76	-25.22	- 1.22	.38
		87	1964	-334.20	3.36	-51.38	10.35	-50.76	- 5.56	.48
Local alluvial	0	46	1963	- 80.81	- .36**	- 7.00	- 1.74	29.98	52.58**	.25
		46	1964	367.06	- 8.69	110.14**	-18.95**	365.30	-31.13	.40

** *t*-test significant at P = .05

Table 57. Proximate chemical content percentages for oven-dry fruit

	Crude Protein	P	K	Ca	Mg	Fe	Zn	Fat	Fiber	Ash
French mulberry	5.495	.121	1.335	.260	.15	.0090	.0030	11.5	28.1	3.4
Dogwood	5.725	.124	.895	1.600	.18	.0060	.0024	17.1	35.2	5.8
Parsley hawthorn	7.825	.138	1.135	1.575	.25	.0060	.0034	7.1	32.3	5.4
Hawthorn	3.790	.089	1.190	.714	.15	.0060	.0018	4.3	32.6	4.0
Yaupon	6.155	.102	1.245	.235	.26	.0075	.0030	13.1	25.7	3.3
Mexican plum	3.960	.078	1.490	.180	.07	.0075	.0028	4.8	24.1	3.4
Blueberry	5.590	.083	.680	.220	.08	.0060	.0021	9.9	16.9	2.0
Tree huckleberry	3.395	.061	.670	.240	.06	.0075	.0020	11.8	17.7	2.1
Arrowwood	6.380	.139	1.475	.460	.17	.0060	.0027	26.5	13.3	4.3

largest amount of magnesium, and French mulberry ranked first in iron content. The fruit containing the largest per cent of zinc was parsley hawthorn. Arrowwood fruit consisted of 26.5 per cent fat, the highest percentage. The highest content of fiber and ash was obtained in the analysis of dogwood fruit.

Statistical analyses of the species which had a sufficient number of observations to run a multiple regression analyses and a combined analysis of all samples were not conclusive. As shown in Tables 58, 59, 60, and 61, the R^2 values varied from .02 to .45. This indicates that the independent variables used in the analyses have little relationship to variations in chemical content. The formulas show that the values of the independent variables are very small, so that a unit change in a variable has very little effect on the chemical content. Because the highest R^2 value was less than .5, the equations obtained from the multiple regression analyses were not accurate enough to be useful for prediction purposes.

Table 58. Formulas, obtained from multiple regression analysis of data, predicting crude protein content of oven-dry fruit

Species	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
French mulberry	146	1963	.447	-.02**	- .02	.33**	.23	.40**	.14
	428	1964	5.023	.001	-1.00**	.10	-.01	-.04	.04
Dogwood	17	1963	7.31	-.03	.55	-.06	-.13	.08	.23
	16	1964	3.48	.04	.25	-.12	-.02	.06	.06
Arrowwood	29	1963	3.93	.006	- .75	.11	.27	-.16	.05
	22	1964	-1.04	.02	1.71	.11	.02	.03	.10
All species	221	1963	1.67	-.02**	- .99**	.18	.13	.27**	.16
	499	1964	5.29	.005	.18	.02	-.13	-.14**	.09

** t-test significant at P = .05

Table 59. Formulas, obtained from multiple regression analysis of data, predicting phosphorus content of oven-dry fruit

Species	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
French mulberry	146	1963	.013	-.0005**	-.04	.007**	.003	.009**	.13
	428	1964	1.16	-.0002	-.30**	.009	-.03	.03**	.07
Dogwood	17	1963	.100	-.001	.01	-.002	-.002	.009	.39
	16	1964	-.103	.009	.01	-.01	.02	.05	.21
Arrowwood	29	1963	.057	.0005	-.02	.004	.004	-.003	.07
	22	1964	-.137	.004	.38	.005	.006	.02	.08
All species	221	1963	.04	-.0003**	-.02**	.004	.001	.007**	.15
	499	1964	1.21	.001	.09	-.02	-.03	-.02	.10

** <u>t</u>-test significant at P = .05

Table 60. Formulas, obtained from multiple regression analysis of data, predicting potassium content of oven-dry fruit

Species	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
French mulberry	146	1963	.145	-.005**	-.53**	.08**	.04	.10**	.13
	428	1964	1.295	.0007	-.26**	.007	-.02	.01	.07
Dogwood	17	1963	.755	.0001	.14	-.02	-.02	.01	.27
	16	1964	.537	.009	.12	-.02	-.001	-.03	.20
Arrowwood	29	1963	.558	.003	-.16	.05	.08	-.04	.09
	22	1964	-.299	.005	.40	.03	.009	.005	.11
All species	221	1963	.40	-.005**	-.27**	.05**	.007	.07**	.13
	499	1964	1.38	.001**	.03	-.008	-.05**	-.03**	.22

** t-test significant at P = .05

Table 61. Formulas, obtained from multiple regression analysis of data, predicting calcium content of oven-dry fruit

Species	Number Samples	Year	B_0	X_1	X_2	X_3	X_4	X_5	R^2
French mulberry	146	1963	.046	-.001**	-.07	.01	.01	.02**	.13
	428	1964	.285	-.0001	.002	-.02**	.01	-.0001	.02
Dogwood	17	1963	.879	-.01	-.06	.09	-.13	.09	.25
	16	1964	-.158	.02	.02	.02	-.06	.05	.23
Arrowwood	29	1963	.026	.003	-.09	.01	.03	-.007	.11
	22	1964	.011	.002	.12	.007	-.01	-.0006	.07
All species	221	1963	-.055	-.001**	.12**	.025**	.008	.01	.45
	499	1964	.097	.001**	.20**	.003	.01	-.01	.29

** *t*-test significant at P = .05

DISCUSSION

Results of study

The most apparent result of this investigation was the large percentage of variation in fruit yields which can be divided into the three following categories: (1) variations between years, (2) variations between sampling units located within different habitats (soil types, tree basal areas, and/or tree canopy conditions), and (3) variations between units located in apparently identical environments. It seems that external factors such as weather conditions, disease, or insects would be the primary causes of between-year variations. The differences in yield between units located within different habitats could be the result of competition for soil moisture, nutrients, and light. Variations of the third type cannot be explained as easily, but two sources of variation could be the age and vigor of the individual plants and competition with lesser vegetation. Fruit production variations of plants growing under natural conditions have been reported on all investigations dealing with yield.

The inability to obtain significant statistical results when analyzing data acquired during this study has been disappointing. Although five independent variables were used in the multiple regression analysis, it became evident that other factors also influenced yields and chemical contents of the fruit. Three such factors not incorporated in this study are: temperature, especially during flower and fruit-set periods; soil fertility; and competition with other understory plants and tree reproduction. A sampling method which included more samples on certain species would have improved the data analysis. The statistical design did not permit an analysis of interaction between tree basal area classes, tree canopy conditions, and soil types. It is possible that better results could have been obtained if the study had continued for several years. Fewer sampling units of larger size and more intensive inventory of all factors that might affect fruit yield and chemical content might have produced better results.

Fruit production of domestic plants versus wild plants

Environmental differences are one of the most important factors to consider when comparing the yields of cultivated and wild plants. Man attempts to provide the environment which will result in maximum yield from domesticated fruit-producing trees and shrubs. The plants are spaced to prevent competition; whereas, wild plants usually have to compete for space, moisture, nutrients, and light in a forest community. Domestic fruit trees are pruned in order to maintain proper root-crown ratios, open crowns for better light penetration, and removal of unthrifty branches. Natural pruning of wild plants is usually a slow process in which only the most unthrifty branches die. Bee hives are placed in many orchards to assure better flower pollination and increased fruit yield which is usually superior to the natural pollination of wild plants. Herbicides and insecticides are used to protect the fruit trees from diseases and insects; smog pots and other methods are used to prevent damage from late freezes; and irrigation is used to maintain suitable soil moisture during droughts.

These are only a few methods used in maintaining ideal environmental conditions in orchards which wild plants do not receive.

Another procedure for obtaining higher and more consistent yields of fruit trees is the crossing of varieties which produce hybrids of superior quality and/or increased disease and insect resistance. Once a suitable hybrid is developed, it is reproduced asexually so that its desirable qualities are maintained. Although these plants produce superior and consistent yields, they would not survive long without the protection and care of man. Wild plants survive without any attention from man; in fact, many survive and produce fruit crops in spite of man's attempts to eliminate them from the vegetation communities.

Wild plant seeds fall to the ground or are dropped by various animals and only germinate when subjected to the proper environmental factors. When the seeds germinate, the new plant must be able to survive and grow if it is to produce fruit. Fruit or orchard plants, on the other hand, are planted in especially prepared areas and are watered, cultivated, and fertilized in order to assure their survival and subsequent fruit production. Domestic fruit trees produce a larger and more consistent fruit crop than wild plants because of the additional care they receive.

Ecological significance

Plants must flower and produce fruit in order to perpetuate their own kind. Certain physiological processes which proceed initiation of the reproduction cycle are controlled largely by external factors such as light, temperature, soil nutrients, and moisture. These external factors extend their influences into many processes of the living plant, including photosynthesis, formation and movement of auxins, floreign, enzymes, and other growth substances. This in turn regulates the growing period, shoot and root growth, flowering, fruit "set", and fruit development. A shortage or an excess of any external controlling factor will upset the highly organized growth and reproduction cycle of a plant.

Two definite trends existed in the fruit production of the study plants. Fruit yield decreased as the tree basal area increased, which indicated the effect of competition on fruit production. A reduction of fruit yield also occurred as the ecological succession progressed toward the climax forest, as indicated by the tree canopy condition. The climax forest of this area is a mixed oak-hickory-beech type with a dense canopy which would allow little light penetration. Low light intensities at ground level would cause a reduction of the ground flora. Fruit production by canopy conditions indicated that the best ecological stages for fruit yield were the shrub or brush stage (overhead canopy absent) or when an overstory of intolerant to mid-tolerant trees existed. The study plants, because of their shade tolerance, existed under a wide range of shaded conditions, but as plant succession progressed toward the climax forest a reduction of plant vigor and fruit production occurred.

Nutritional requirement for flowering and fruiting

It is possible that some of the fruit yield variations can be attributed to the relative proportion of carbohydrates and nitrogen within the plant at the time of bud formation. According to Klebs, as reported by Busgen (1917) and Kramer and Kozlowski (1960), the carbohydrate-nitrogen ratio governs the promotion of flower formation and subsequent fruit production. Research by Krus and Kraybill, as discussed by Kramer and Kozlowski (1960) and Audus (1963), resulted in the theory that the initiation of flowering was attributed to the attainment of a certain balance between the carbon and nitrogen nutrition of the plant. Talbert (1949) stated that experiments have shown a certain relationship must exist between carbohydrates and nitrogen within the plant before good growth and fruiting can be obtained.

A shift of the C:N (C - carbohydrates and N - nitrogen) within the plant may occur from one year to the next depending upon the weather, soil moisture and soluble salts, disease, and insects. According to the theory, any of these external factors which result in an increased proportion of carbohydrates through more rapid photosynthesis or a reduction of respiration will tend to promote flower bud formation. Dry, exposed sites and/or a hot, dry season should favor increased photosynthesis which would then promote the formation of flower buds. Severe insect or disease damage to foliage and/or a wet growing season would necessarily reduce the ratio of carbohydrates to nitrogen through reduced photosynthesis and increased absorption of soluble salts from the soil. This situation would increase the vegetative growth of the plants and reduce the formation of flowers.

The C:N balance, as a regulator of fruit production, could possibly explain some of the variations in fruit yield between years, by tree basal area classes, and tree canopy conditions. For example, a wet, cloudy growing season would restrict photosynthesis through decreased sunlight intensities, and the increased soil moisture would promote the absorption of soluble salts. This condition would promote vegetative growth and reduce fruit production. A hot, dry year would reverse the C:N and promote the formation of flower buds and restrict vegetative growth, and this would increase the fruit production.

An increase in tree basal area or tree crown density would normally reduce the amount of light reaching the understory vegetation. This would restrict the rate of carbohydrate manufacture and affect the C:N. Most of the plants included in this study were shade tolerant, and full sunlight was not necessary for maximum photosynthesis. For example, maximum photosynthesis occurs in flowering dogwood at one-third of full sunlight; therefore, an excess of sunlight would restrict the assimilation of carbohydrates as much or more than insufficient light. This could explain why some of the study plants produced more consistent crops and higher fruit yields under forest stands than under exposed conditions. The shade tolerance of a plant and its ability to adapt to various intensities of light would, under these circumstances, determine the range of conditions under which an individual plant could produce fruit.

It is known that some plants produce high fruit yields only after a reserve supply of carbohydrates has accumulated over two or more years. When applied to the study plants, this would account for some of the between-year variations in fruit yields for such plants as flowering dogwood, arrowwood, and hawthorn. A detailed study of all factors, external and internal, which affect fruiting must be carried out on each plant species before fruit yield variations can be understood and predicted with any accuracy. Variations in plant fruit production cannot be explained by a general statement, as each plant species seems to have its own special requirements which must be met before fruit production occurs. Even after a fruit crop becomes established, it can be lost through the effect of diseases, insects, extremes in soil moisture, and competition for the foods necessary for proper growth.

SUMMARY

Determinations of the yield and chemical content of fruit produced by selected deer-browse plants found in a loblolly-shortleaf pine-hardwood forest in central Louisiana were the primary objectives of this investigation. Belt transects 79.2 by 6.6 feet were established on a grid pattern within the 540-acre study area. Each transect plot was divided into three consecutive 4-milacre units. An inventory of the units included the number, diameter, crown depth, and crown width of 12 species of study plants; tree basal area per acre; and tree canopy condition. Soil type of each unit was determined from a soil type map prepared by the U. S. Soil Conservation Service. All data were recorded directly on IBM code sheets.

The total fruit crops produced by the study plants located on the 1080 units were collected in 1963 and 1964 when the fruit began to mature. Field and oven-dry weights were determined for each sample. Chemical analyses were made on all samples which had an oven-dry weight equal to or above 4 grams. The proximate content of crude protein, phosphorus, potassium, and calcium were determined by chemical analyses in the Louisiana State University Feed and Fertilizer Laboratory.

A phenological study of the flowering and fruiting characteristics was made of the study plants. Attempts were made to visit the research area bi-monthly during the growing season in order to examine the plants and take photographs of the flowers or fruit present.

A summary of data collected on each study species will be presented individually.

French mulberry

There was a very wide yearly difference in fruit yields of French mulberry. For each plant that produced fruit, the average yield was 4.32 grams in 1963 and 5.13 grams in 1964, but in 1963 only 873 stems produced fruit compared to 2183 in 1964. Yield of fruit per acre was 832.7 grams for 1963 and 2,590.0 grams for 1964.

When fruit production was determined for tree basal area classes, tree canopy conditions, and soil types, there was an indication that all these factors affected yield. Generally, the greater the tree basal area, the less the yield; the multistoried overhead canopy reduced the yield most; and dry sites reduced the yield during periods of moisture stress. Results of the study seem to indicate that competition with other plants for moisture and light has a regulating influence on the fruit production of French mulberry.

Low coefficient of determination values for the regression analyses of fruit yield indicated that tree basal area accounted for only a small percentage of variations in yield. Multiple regression accounted for a higher percentage of the variation, but the multiple coefficient of determination values indicated that the formulas could not be used to accurately predict yields.

Results of the chemical analyses revealed a wide variance in the per cent of crude protein, phosphorus, potassium, and calcium, but the cause of this variation was not determined. From 573 different analyses, the oven-dry fruit of French mulberry contained the following percentages: crude protein, 5.335; phosphorus, .1183; potassium, 1.321; and calcium, .250.

The fruit was available for animal utilization from the time it began to ripen in mid-August until the latter part of December.

Dogwood

The fruit yield of flowering dogwood in 1964 was 2,082.8 grams of fruit collected from 17 plants compared to 985.7 grams from 21 plants in 1963. Sixteen of these plants produced fruit both years. Average yield of fruit per acre was 227.5 grams in 1963 and 482.5 grams the second year.

After the yields were determined for each tree basal area class, tree canopy condition, and soil type, attempts were made to correlate the effect of these factors on fruit yield. Above-average yields were obtained from plants in three basal area classes in 1963 and two in 1964. Fruit crops were above normal both years on plants in a forest which had a basal area of 80 square feet. Highest yields were obtained when the tree canopy was an overstory, which should indicate the best condition for fruit production. Plants on the same soil types produced the best crops each year, except for those on the Beauregard (3-5 per cent slope) which only produced fruit in 1963. The highest yield, 3,840.3 grams per acre, was produced on local alluvial soils in 1964.

It seems that a moderately stocked stand of timber with an overstory canopy and a basal area of about 80 square feet presents the best condition for consistent fruit production. Moist, well-drained soils produced the best crops.

No attempt was made to determine the basis for the wide variations in chemical contents of the 33 samples. The chemical content means in per cent of oven-dry weights were: crude protein, 5.725 per cent; phosphorus, .124 per cent; potassium, .895 per cent; and calcium, 1.60 per cent.

Flowering dogwood fruit abscission began soon after maturity; therefore, the fruit was only available on the tree for a short length of time. Once it fell to the ground, the fruit was available to all ground-feeding animals.

Hawthorn

Fruit yields of hawthorn varied greatly between the two years' collections. Hawthorns produced 188.5 grams of fruit per acre in 1963 and only 19.5 grams per acre the following year. Part of this variation was due to a higher insect infestation in 1964.

Little trend in fruit yield could be established when the yields were classified according to tree basal area, tree canopy condition, and soil type. Better-than-average production rates were obtained under tree basal areas of less than 60 square feet. More consistent production was obtained under a multistory pine-hardwood canopy, but the best yield in 1963 was obtained from areas with no canopy. Generally, multistory or midstory pine-hardwood canopies provided the best conditions for fruit production when both years are taken into consideration. Yields were not consistent between years according to soil types. Most consistently producing plants were located on the Sawyer (1-3 per cent slope) soils. Plants on Beauregard (3-5 per cent slope) soils had the highest yield in 1963 but no fruit in 1964.

The chemical contents of parsley hawthorn were much higher than the other hawthorns. Average percentages of oven-dry fruit from nine parsley hawthorn samples were: crude protein, 7.83; phosphorus, .138; potassium, 1.14; and calcium, 1.58. Fourteen hawthorn fruit samples, excluding parsley hawthorn, had mean chemical contents of 3.79 per cent crude protein, .089 per cent phosphorus, 1.19 per cent potassium, and .72 per cent calcium.

Fruit remained available for animal use from the time it began to mature in September until the latter part of December. It is possible that some of the wormy fruit which dropped early was utilized by wildlife before it deteriorated.

Yaupon

Although yaupon is classed as an important deer-browse plant, the inventory showed only ten plants on the study units. This low density limits its value to deer in the study area. The average fruit yield per acre was 14.8 grams in 1963 and 38.5 grams in 1964.

The low density of plants did not provide adequate data for studying the effect of tree basal area, tree canopy condition, and soil type on fruit production. Best yields were obtained under a pine overstory canopy, but no generalizations could be made on the effects of tree basal areas. Fruit was produced on the Cuthbert (3-5 per cent slope) soil both years. Additional samples might have entirely different results.

Chemical analyses of six samples indicated that the 1963 fruit crop, when compared to that of 1964, contained higher percentages of crude protein, phosphorus, potassium, and calcium. Means of all samples were: 6.155 per cent crude protein, .102 per cent phosphorus, 1.245 per cent potassium, and .235 per cent calcium.

Mature fruit remained firmly attached to the plants; therefore, it was available for animal utilization over a long period of time. All fruit had disappeared by mid-January.

Mexican plum

Although 19 Mexican plum plants were located on the study units, only three produced fruit in 1963. Worm infestation caused a complete loss of the fruit crop in 1964. The calculated yield of fruit in 1963 was 398.4 grams per acre.

Fruit crops were produced under only two tree basal area conditions. A yield of 2,288.5 grams per acre was obtained under a forest whose basal area was 80 square feet per acre, and units with a tree basal area of 70 produced 29.0 grams of fruit per acre. Fruit was produced when the canopy was absent or present as a multistory pine-hardwood or midstory hardwood canopy. Plants on the Beauregard (3-5 per cent slope) soil produced most of the fruit crop.

The chemical contents of Mexican plum fruit were obtained from analyses of three samples. Results of the chemical analyses indicated the oven-dry fruit contained 3.96 per cent crude protein, .078 per cent phosphorus, 1.49 per cent potassium, and .18 per cent calcium.

The fruit remained attached after it matured; therefore, it was available to wildlife over an extended period of time. Mexican plum was not a consistent fruit producer during this study because of its susceptibility to attacks by insects which destroyed the fruit.

Blueberry

Blueberry was the second most abundant plant on the area, but it ranked sixth in fruit production. In 1964, 138.2 grams of blueberry fruit were collected from the study units which gave a calculated yield of 32.0 grams of fruit per acre. Blueberry fruit had the highest moisture content which was 83 per cent.

When the fruit yields were determined for tree basal area classes, tree canopy conditions, and soil types; the influence of these factors on fruit yield was indicated. Above-average yields per acre were obtained under forest stands which had basal areas of 60, 70, and 130+ square feet per acre, and fruits were produced under four other basal area classes. Plants under a midstory pine-hardwood forest produced 512 grams of fruit per acre which was the best yield by canopy conditions. Two other canopy conditions produced above-average yields. The Cuthbert (3-5 per cent slope) soil produced the highest yield of 100.5 grams per acre. Plants on one other soil, the Bibb-Mantachie type, had an above-average yield.

Variations in chemical content of blueberry were exceptionally wide. According to the 11 samples analyzed, the average percentages of crude protein, phosphorus, potassium, and calcium were 5.59, .083, .68, and .22 respectively.

Blueberry is a plant which flowers and produces mature fruit in the spring and early summer. All of the 1964 fruit crop had disappeared before mid-July. The fruit can be of great value as a wildlife food, because it matures when other foods, especially fruits, are scarce.

Tree huckleberry

Tree huckleberry ranked sixth in fruit production in 1963 and third in 1964. The average yield per acre was 81.5 grams for 1963 and 157.0 in 1964. Of the 82 plants tagged on the study units, 11 produced fruit in 1963 and 19 in 1964.

Fruit yields by tree basal area classes, tree canopy conditions, and soil types indicated that the yield was obtained over a rather wide range of conditions. Plants located on units with a tree basal area of 60 square feet produced a high yield of 418.8 grams in 1963 and only one other basal area class resulted in an above-average yield. The 1964 high yield of 1,031.8 grams per acre was produced under a forest which had a basal area of 50 square feet. All basal area conditions which had a fruit crop in 1963 also had one in 1964. Plants under a midstory hardwood canopy had a high yield of 422.8 grams per unit in 1963 and no other conditions produced above-average yields. Four canopy conditions resulted in above-normal crops in 1964. The lowest-producing canopy condition for both years was the multistory canopy. Only one soil type, the local alluvial, produced better-than-average yields both years. The second best yields, also above-average, were obtained on the Cuthbert (3-5 per cent slope) in 1963 and the Susquehanna in 1964. Five of the soil types had no fruit either year.

The chemical contents of tree huckleberry fruit, based upon the analyses of 17 samples, indicated that the fruit was low in food value. The variation was greater among samples for each year than between years. Mean chemical contents of the oven-dry fruit were: crude protein, 3.40 per cent; phosphorus, .061 per cent; potassium, .67 per cent; and calcium, .23 per cent. Except for potassium, the chemical content percentages were higher in 1963.

The fruit of tree huckleberry will persist on the plant after maturity; therefore, it is available as a food over a long period of time.

Arrowwood

Arrowwood was the third most abundant plant occurring on the study units. According to the inventory, 97 arrowwood plants were located on the plots. Of this total, 29 produced fruit in 1963 and 21 in 1964. The yield of arrowwood fruit per acre was 261.0 grams in 1963 and 122.0 in 1964. When compared with the fruit production of the other study plants, arrowwood ranked third in 1963 and fourth in 1964.

Fruit yields were analyzed according to tree basal area classes, tree canopy conditions, and soil types to study the effect of these factors on yield. Although plants in all tree basal area classes produced some fruit, most of the crop was produced where the basal area was less than 100 square feet. For both years, the best yields were obtained when the tree basal area was 50. When the effect of the tree canopy condition was studied, it was found that the best yields for both years were obtained on units without an overhead canopy. The lowest yields were recorded when a pine-hardwood canopy was present, regardless of its position. According to soil types, the highest yield, 846.8 grams per acre, was obtained in 1963 from units on local alluvial soils. The highest yield in 1964 was recorded on the Sawyer

(3-5 per cent slope) soil. Plants on two soil types did not have fruit either year.

Chemical analyses were made on 51 samples of oven-dry fruit. Twenty-nine samples were collected in 1963 and the remaining 22 were obtained in 1964. Variation of chemical contents were greater between samples than between years. The mean chemical contents in per cent of oven-dry weight for the 51 samples were: crude protein, 6.380; phosphorus, .139; potassium, 1.475; and calcium, .460.

Arrowwood fruit was mature by October 20 and some of it remained on the plants until December. It was readily available for animal utilization during this time.

Muscadine

Only two muscadine plants on the study unit bore mature fruit in 1963, and the entire fruit crop in 1964 was eaten by animals before the fruit matured. Average yield of fruit for 1963 was 4.1 grams per acre. No attempt was made to determine the effect of tree basal area, tree canopy condition, and soil type on production of fruit.

The mean chemical contents in per cent of the oven-dry weight were: crude protein, 4.79; phosphorus, .101; potassium, 1.18: and calcium, .64. Even with only two samples, the variation in chemical content was great.

The fruit of muscadine falls soon after it matures. Many animals utilized the fruit as a food, but during this study muscadine was not a very high fruit producer on the study area.

Blackberry

Blackberry is important as food and cover for many species of wildlife. During the inventory, blackberry plants were found on 48 of the study units. Since the fruit matures in the late spring or early summer, the 1963 fruit crop was gone before this study was organized and no fruit was found on the study area the following year. Blackberry plants grow best in openings created by abandoned farms, logging operations, and dead or wind-thrown trees.

Rusty blackhaw

Rusty blackhaw fruit is of some value as a wildlife food, and the foliage is eaten by deer. During the inventory of the study units, ten plants were found growing on the plots. No flowers or fruit were found on any of the tagged study plants during this investigation; therefore, no yield or chemical content data were obtained.

Combined fruit yields

The study plants on the units produced a crop of fruit in 1963 which totaled 8,675.6 grams. In 1964, the entire crop weighed 14,849.5 grams. Yield per acre for the consolidated fruit crop was 2,008.2 grams in 1963 compared to 3,427.4 grams in 1964. French mulberry produced the highest yield both years. With all plants, there was a wide variation in fruit production between years. Four species had higher yields in 1964.

When the yields were classed according to tree basal area, tree canopy condition, and soil type, the overall effect of these factors became evident. Generally, the lower the tree basal area, the higher the production rate of understory plant fruit. The variation in yields between years was much greater when the basal area was 90 square feet per acre and above. Better-than-average yields were maintained over a wider range of basal area classes in 1964. As the tree canopy conditions were considered, it became apparent that over 80 per cent of the fruit crop was produced when the overhead canopy was absent or present as an overstory. More study plants produced fruit when the canopy was absent than under any other condition. French mulberry and dogwood produced fruit under a wider range of canopy conditions than any of the other study plants. The least productive condition was the mixedstory hardwood canopy. When the plants were grouped by soil types, the same two soils had the highest yields both years. The greatest variety of plants produced fruit on the Cuthbert (3-5 per cent slope) soil. Fruit production on the Sawyer soils varied the most.

The proximate chemical content of the fruit varied more between samples within year than between years for each species. Average content of crude protein, phosphorus, potassium, and calcium for the fruit of each species was obtained from all samples analyzed in the laboratory. Composite samples were analyzed in determining the content of magnesium, iron, zinc, fat, fiber, and ash. These results are summarized on page 185 in Table 57.

Results of the multiple regression analyses indicated that factors other than those used as independent variables have an effect on fruit production of understory plants. The coefficient of determination values, which indicate the amount of variation included in the independent variables, revealed that the prediction equations were of no value in estimating yields or chemical contents.

CONCLUSIONS

Although the results obtained during this investigation were somewhat varied, several generalizations can be made concerning the yield and chemical content of fruit produced by deer-browse plants in a pine-hardwood forest. These generalizations or conclusions are:

1. During the two years of this study, the results indicated that there was a wide variation in total fruit production between years. Some species produced good crops, while in the same year other species had poor fruit crops. This phenomenon prevented extreme variations in total fruit yield.
2. French mulberry was the most common plant and the heaviest fruit producer included in this study. Some French mulberry fruit was produced under all types of habitat conditions.
3. Usually, as the tree basal area increased, the amount of fruit produced by the understory plants decreased. There was a greater percentage variation in fruit yield between years at higher basal areas.
4. Best fruit productions were obtained when the tree canopy was absent or present as an overstory of large mature trees. More than 80 per cent of the fruit yield was obtained under the above conditions. The lowest production of fruit occurred on plants growing under a multistoried forest.

5. There was a wide variation in fruit yields on different soil types. It is suspected that this was related to the soils' water-holding properties. Some soils had a wide variation of fruit yield between years while others did not.
6. The fruit chemical contents of a species varied widely between samples from different plants within the same year. The average contents of fruit from the same species varied little between years. Generally, the chemical contents were slightly higher in 1963, which was a dry year; whereas, the moisture contents were higher in 1964.
7. All fruit produced by the study plants have some value as deer food. Samples of collected fruit were readily eaten by captive deer. Field observations indicated that deer utilized French mulberry and Mexican plum fruit.
8. Factors other than the independent variables included in this investigation influence the production of fruit.

Since this type of fruit is important to many wildlife species, a more thorough knowledge of factors influencing fruit crops should be known. More research projects to determine actual yields should be undertaken, and these projects should extend over a period of several years.

LITERATURE CITED

Audus, L. J. 1963. Plant growth substances. Leonard Hill (Books) Limited, London and Interscience Publishers, Inc., New York.

Baskett, T. S., R. L. Dunkerson, and S. C. Martin. 1957. Responses of forage to timber stand improvement in the Missouri Ozarks. Journ. Wildl. Mgmt. 21(2):121-126.

Blair, R. M. 1960. Deer forage increased by thinnings in a Louisiana loblolly pine plantation. Journ. Wildl. Mgmt. 24(4):401-405.

Browne, C. A. 1938. Some relationships of soil to plant and animal nutrition - the major elements. U. S. Dept. Agric. Yearbook 1938. p. 777-806.

Bubeník, A. and J. Lochman. 1956. [Food consumption and daily rhythm of food intake of roe and red deer] Z. Jagdwissensch 2(3):112-118. (From Wildlife Review 87:43)

Busgen, M. 1917. Structure and life of forest trees. London and Norwich Press, Limited, Norwich.

Caillouet, C. W. 1960. Nutrient content of some seeds and fruits utilized as food by wildlife in Louisiana. M. S. Thesis. La. State Univ., Baton Rouge. 72 p.

Davison, V. E., K. E. Graetz. 1957. Managing habitat for white-tailed deer and wild turkey. Trans. 22nd. N. Am. Wildl. Conf. p. 412-424.

Dalke, Paul D. 1953. Yield of seeds and mast in second growth hardwood forest of southcentral Missouri. Journ. Wildl. Mgmt. 17(3):378-380.

Dewitt, J. B. and J. V. Derby, Jr. 1955. Changes in nutritive value of browse plants following forest fires. Journ. Wildl. Mgmt. 19(1):65-70.

Dunkerson, R. L. 1955. Deer range appraisal for the Missouri Ozarks. Journ. Wildl. Mgmt. 19(3):358-364.

French, C. E., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Pa. State Univ. Agric. Exp. Sta. Bull. 600. 50 p.

Goodrum, P. D. and V. H. Reid. 1958. Deer browsing in the longleaf pine belt. Proc. Soc. Am. Foresters. p. 139-143.

_______________ 1962. Browsing habits of white-tailed deer in the Western Gulf region. Proc. First Natl. White-tailed Deer Disease Symp. Univ. of Georgia. p. 9-14.

Gysel, L. W. 1957. Effects of different methods of releasing pine on wildlife food and cover. Down to Earth 13(2):2-3.

Gysel, L. W. and W. A. Lemmien. 1964. An eight-year record of fruit production. Journ. Wildl. Mgmt. 28(1):175-177.

Halls, L. K. and H. S. Crawford, Jr. 1960. Deer-forest habitat relations in North Arkansas. Journ. Wildl. Mgmt. 24(4):387-395.

Halls, L. K. and T. H. Ripley (Editors). 1961. Deer-browse plants of southern forest. U. S. Forest Serv., South. and Southeast. Forest Expt. Stas. 78 p. illus.

Harlow, R. F. 1959. An evaluation of white-tail deer habitat in Florida. Fla. Game and Fresh Water Fish Comm. Tech. Bull. 5. 86 p. illus.

_______ 1961. Fall and winter foods of Florida white-tailed deer. Quart. Journ. Fla. Acad. Sci. 24(1):19-38.

Hellmers, H. 1940. A study of monthly variation in nutritive value of several natural winter deer foods. Journ. Wildl. Mgmt. 4(3):315-324.

Holloway, J. T. 1950. Deer and the forest of Western Southland. New Zealand Journ. Forestry 6(2):123-137.

Hoover, K. B. 1961. Hawthorn studies in Pennsylvania in relation to wildlife values. Pa. Coop. Wildl. Res. Unit. Agric. Expt. Sta. Pa. State Univ. Spec. Report 5. 58 p.

Hundley, L. R. 1959. Available nutrients in selected deer-browse species growing on different soils. Journ. Wildl. Mgmt. 23(1):81-90.

Korschgen, L. J. 1952. Food of Missouri deer, with some management implications. Journ. Wildl. Mgmt. 26(2):164-172.

Kramer, P. J. and T. T. Kozlowski. 1960. Physiology of trees. McGraw-Hill, New York.

Lay, D. W. 1955. Effects of prescribed burning on forage and mast production in southern pine forest. Pro. Ninth Ann. Conf. Southeast. Assoc. of Game and Fish Comm. p. 1-18.

Lay, D. W. 1956. Some nutritional problems of deer in the southern pine type. Proc. Tenth Ann. Conf. Southeast. Assoc. of Game and Fish Comm. p. 53-58.

__________ 1961. Fruit production of some understory hardwoods. Proc. Fifteenth Ann. Conf. Southeast. Assoc. of Game and Fish Comm. p. 30-37.

__________ 1962. Deer fruit in the pine woodlands. Texas Game & Fish 20(1):8-11.

__________ 1965. Fruit utilization by deer in southern forests. Journ. Wildl. Mgmt. 29(2):370-375.

Leopold, A. S. 1936A. Deer and dauerwald in Germany. I. History. Journ. Forestry 34(4):366-375.

______________ 1936B. Deer and dauerwald in Germany. II. Ecology and policy. Journ. Forestry 34(5):460-466.

______________ 1950A. Deer in relation to plant succession. Journ. Forestry 48(10):675-678.

______________ 1950B. Deer in relation to plant succession. Trans. 15th. N. Am. Wildl. Conf. p. 571-578.

McEwen, L. C., C. E. French, N. D. Magruder, R. E. Smith, and R. H. Ingram. 1957. Nutrient requirements of the whitetail deer. Trans. 22nd. N. Am. Wildl. Conf. p. 119-130. illus.

Mikola, P. 1958. [Developing Finland's forest as the environment of game]. Suomen Riista 12:125-136. (From Biolog. Abstracts 35:20322).

Murphy, D. A. and J. H. Ehrenreich. 1965. Fruit-producing trees and shrubs in Missouri's Ozark forest. Journ. Wildl. Mgmt. 29(3): 497-503.

Park, B. C. 1942. The yield and persistence of wildlife food plants. Journ. Wildl. Mgmt. 6(2):118-121.

Parsons, A. C. 1955. The wild blackberry. Amer. Forests 6(61):24-25, 40. illus.

Patton, D. R. 1963. Forest cutting and its influence on browse production. Va. Journ. Sci. 14(4):208.

Pearson, A. M. 1943. White-tails like acorns. Ala. Conserv. 15(6):8-9, 12.

Phillips, G. W. 1959. The familiar hawthorns offer both fruit and flower. Horticulture 37(1):18-19.

Protoklitova, T. V. 1961. [Plant foods of the spotted deer of the Khopersk Forest Preserve] Tr. Khopersk Gos. Zapovednika 5:139-172. (From Biolog. Abstracts 44(1):481).

Schuster, J. L. and L. K. Halls. 1963. Timber overstory determines deer forage in shortleaf-loblolly pine-hardwood forest. Soc. Amer. Foresters Proc. 165-167.

Scott, P. R. M. and C. D. Fowle. 1952. The correlation of silvicultural systems and wildlife management. Forest Chron. 28(4): 79-87.

Severinghans, C. W. and E. L. Cheatum. 1961. The life and times of the whitetail deer. p. 189-218 in W. F. Taylor, The deer of North America. Stockpole Co., Harrisburg, Penn. and Wildl. Mgmt. Inst., Washington, D. C.

Smith, F. H., K. C. Beeson, and W. E. Price. 1956. Chemical composition of herbage browsed by deer in two wildlife management areas. Journ. Wildl. Mgmt. 20(4):359-367.

Spinner, G. P. and J. S. Bishop. 1950. Chemical analysis of some wildlife foods in Connecticut. Journ. Wildl. Mgmt. 14(2):175-180.

Swank, W. A. 1956. Protein and phosphorus content of browse plants as an influence of southwestern deer herd levels. Trans. 21st. N. Am. Wildl. Conf. p. 141-158.

Talbert, T. J. 1949. General horticulture. Lea and Febiger, Philadelphia.

Vimmerstedt, J. P. 1957. Silvical characteristics of flowering dogwood (Cornus florida L.). U. S. Forest Serv. Southeast. Expt. Sta. Paper 87. 11 p.

Wainio, W. W. and E. B. Forbes. 1941. The chemical composition of forest fruits and nuts from Pennsylvania. Journ. Agri. Res. 62(10):627-635.

Wilde, S. A. 1946. Soil fertility standards for game food plants. Journ. Wildl. Mgmt. 10(2):77-81.

Winkler. 1935. Beiträge Zur Verbesserung der Lebensbedingungen des Wildes - besonders der des Rotwildes - im deutschen Walde. Tharandter Forstl. Jahrb. 86(7):349-400. (From Biolog. Abstracts 10(4):1002).

APPENDIX

SOIL DESCRIPTIONS

The following soil descriptions are taken from established series as published by the National Cooperative Soil Survey, USA or the Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture. The complete series descriptions are not presented here.

BEAUREGARD SERIES

The Beauregard series consists of moderately well drained Red-Yellow Podzolic soils developed in sandy and silty materials of the Coastal Plain. These soils are closely associated with the Rains, Caddo, Bowie, Norfolk, Ruston, Ora, Savannah, and Pheba soils. Beauregard soils lack the fragipans that are characteristic of the Ora, Savannah, and Pheba series. They are better drained than the Rains and Caddo and are browner and less mottled in the upper part of the B_2 horizon. They are not as well drained as the Bowie, Norfolk, and Ruston soils and have gray mottling at shallower depth than the Bowie soils. They resemble the Goldsboro soils in color and degree of drainage but contain more silt and limited data indicate that they have somewhat higher base saturation. The Beauregard soils are extensive and are important to agriculture.

Soil Profile: Beauregard very fine sandy loam - pasture

A_{p1} 0-3" Dark grayish-brown very fine sandy loam; weak medium granular structure; very friable; medium acid; clear wavy boundary. 2 to 5 inches thick.

A_{p2} 3-8" Light yellowish-brown very fine sandy loam with few fine mottles of pale brown; weak medium granular structure; very friable; very porous; strongly acid; clear wavy boundary. 2 to 5 inches thick.

B_1 8-12" Pale-brown light sandy clay loam with a few medium prominent mottles of brownish yellow; weak fine blocky structure; friable; few thin clay films; few fine hard concretions and common soft concretions with yellowish-red centers; strongly acid; gradual wavy boundary. 2 to 6 inches thick.

B_{21} 12-19" Yellowish-brown clay loam with few medium mottles of pale brown and occasional red mottles where soft concretions are broken; weak fine blocky structure; friable; slightly plastic; few fine hard concretions; few tubular pores; patchy clay films; strongly acid; diffuse boundary. 4 to 12 inches thick.

B_{22} 19-41" Mottled yellowish-borwn and gray clay loam with few red mottles; weak medium blocky structure; friable; slightly plastic; few tubular pores; few patchy clay films; few fine hard concretions; strongly acid; gradual wavy boundary. 12 to 30 inches thick.

C 41-50" Light-gray sandy clay loam with common coarse mottles of yellowish brown and few mottles of red; weak medium to coarse blocky fragments; strongly acid.

Range in Characteristics: The most common types are very fine sandy loam and silt loam. Other textural grades of sandy loam are recognized. Color of the undisturbed A_1 horizon ranges from very dark gray to grayish brown, that of the A_p horizon from dark grayish brown to grayish brown or brown. Color of the A_2 horizon ranges from gray to light yellowish brown and mottling may be absent. Color of the B_1 horizon, if present, ranges from very pale brown to light yellowish brown or brown, and mottling may be absent. Texture of the B_1 horizon, when present, may be silt loam, very fine sandy loam, light sandy clay loam, or light silty clay loam. Dominant color of the B_{21} horizon ranges from strong brown or brown to brownish yellow; there may be few gray or grayish-brown mottles. Texture of the B_{21} horizon may be sandy clay loam or silty clay loam. The red mottles noted in the B and C horizons are not always present and are not essential to the series. The concretions noted may not be readily observed in any given horizon or may be common in some. Colors stated are for moist soil. Colors of dry soils will be one or two units of value higher.

Topography: Nearly level to gently sloping, with slopes ranging from 1 to 5 per cent. Dominant slope is about 2 per cent.

Drainage and Permeability: Moderately well drained. Slow to medium runoff, medium internal drainage, and slow to moderately slow permeability.

Vegetation: Pine or mixed pine and hardwood.

Series Established: Beauregard Parish, Louisiana, 1928.

BIBB SERIES

The Bibb series consist of Low-Humic clay soils of the flood plains. These soils are derived from recent alluvium washed chiefly from a large number of sandy to moderately fine textured soils of the Coastal Plain Uplands. The Bibb series is the light colored, gray, poorly drained member of a drainage sequence that includes the well drained Ochlockonee, the moderately well drained Iuka, and the somewhat poorly drained Mantachie series. Bibb soils are also associated with the Urbo and Chastain soils in stream flood plains. Bibb soils are grayer and more poorly drained and coarser textured than the Urbo soils. They are comparable in drainage to the Chastain soils but are coarser textured throughout the control section. The Bibb soils are widely distributed in relatively large bodies but are of limited importance to agriculture.

Soil Profile: Bibb fine sandy loam

A_1	0-3"	Dark gray fine sandy loam; weak medium granular structure; very friable; many fine roots; few fine black concretions; strongly acid; abrupt smooth boundry. 3 to 5 inches thick.
C_{1g}	3-8"	Gray fine sandy loam with fine distinct mottles of brownish-yellow and faint mottles of light gray; weak fine granular structure; few fine black concretions; strongly acid; clear smooth boundry. 4 to 12 inches thick.
C_{2g}	8-28"	Gray fine sandy loam with common medium distinct mottles of light yellowish-brown and brownish-yellow; structureless; few fine roots; few fine black concretions; strongly acid; gradual wavy boundry. 10 to 40 inches thick.
C_{3g}	28-40"	Gray sandy clay loam with common medium distinct mottles of brownish-yellow, yellowish-brown, and light gray; structureless; few fine roots; few fine black concretions; strongly acid. 2 to 5 feet thick.

Range in Characteristics: Principal types are silt loam, loam, very fine sandy loam, and fine sandy loam; but loamy sand, sandy clay loam and silty clay loam types occur along some of the larger streams. Stratification of sediments may be evident in any profile. The A horizon ranges in dominant color from light gray through dark grayish-brown. The C_{1g} horizon ranges in dominant color from light gray to dark gray, inclusive, commonly with mottles of brown and yellow shades that range from fine through coarse in size. The C horizon within the control section ranges from silty clay loam to sandy clay loam in texture and may consist of thinly stratified beds, ranging from loamy sands to silty clay loam and sandy clay loam. Pockets or strata of gravel may occur in the C horizon. The number of concretions varies from none to many. Reactions changes from very strongly acid to medium acid, inclusive. Colors given are for moist soils.

Topography: Level to nearly level flood plains and upland drainage ways. Slopes range from 0 to 2 per cent.

Drainage and Permeability: Poorly drained with very slow runoff and internal drainage; permeability is moderate or slow. The water table lies at depths of a foot or less for long periods. Subject to frequent flooding and standing water.

Vegetation: Chiefly hardwoods, a few pines.

Series Established: Pike County, Mississippi, 1910.

BOWIE SERIES

The Bowie series consists of Yellow Podzolic Soils having friable subsoils that are yellow in the upper part but splotched or mottled with red in the lower. The parent materials are acid moderately sandy earths of the Gulf Coastal Plain. The principal catenal associates are the Ruston and Caddo series.

Soil Profile: Bowie fine sandy loam

A_0		Loose partly decomposed forest litter resting abruptly on the mineral soil; 1-3 inches thick.
A_1	0-3"	Grayish-brown, dark grayish-brown; (moist); light fine sandy loam; very friable; weak fine-granular; slightly to medium acid; 2 to 4 inches thick.
A_2	3-12"	Very pale brown, pale-brown; (moist); light fine sandy loam; very friable; porous massive; medium acid; 6 to 15 inches thick.
B_{21}	12-20"	Yellow, yellowish-brown; (moist) sandy clay loam; friable; porous massive to weakly blocky; medium to very strongly acid; 4 to 15 inches thick.
B_{22}	20-50"	Yellow sandy clay loam or light sandy clay splotched with red; moderate- to weak-blocky, the blocks having red centers and yellow exteriors; medium to very strongly acid; 22 to 36 inches thick.
C	50"	Parent material of thick- or thin-bedded acid moderately sandy sediments; the color is dominantly yellow or pale yellow banded or spotted with light gray and red.

Range in Characteristics: Depth to B horizon is related to texture of A horizon being 10 to 18 inches in typical sandy loams and 18 to 30 inches in the typical loamy fine sand; where cultivated the A_1 horizon is pale brown (brown to light yellowish brown moist) and extends through plow depth; color of the B_{21} horizon ranges from 2.5Y 6/4 to 7.5YR 7/6 and in places is faintly mottled with pale yellow; in profiles transitional toward Savannah soils the horizons below 30 inches are very weakly cemented; ferruginous concretions or small subangular fragments of ironstone occur throughout the solum in places. Colors given are for dry soils unless otherwise stated.

Topography: Nearly level to gently rolling erosional upland with gradients mostly between 1 and 4% but ranging up to 10; plane to slightly convex or slightly concave; sandy mounds, 10 to 30 feet in diameter and 1 to 2 feet high, occur in some nearly level areas.

Drainage: Runoff is slow to rapid; internal drainage is free to moderate; drainage is wholly adequate and favorable for all common crops.

Vegetation: Pine-oak forest giving way to the west, at about the 40-inch rainfall line, to post oak and blackjack.

Series Established: Bowie County, Texas, 1918.

CADDO SERIES

The Caddo series comprises somewhat poorly (imperfectly) drained Red-Yellow Podzolic soils that have light gray to very pale brown A horizons with mottled yellow and light gray friable sandy clay loam or clay loam B horizons. The Caddo series occur in humid flatwoods sections of the Gulf Coastal Plain associated with better drained Red-Yellow Podzolic soils such as the Bowie, Segno, Ruston and Lakeland series. The parent materials are acid loamy earths (stratified sands, silts and clays) ranging in geological age from early Pleistocene (Lissie formation) to Cretaceous. The associated Bowie and Segno series have less grayish unmottled A horizons and yellowish upper B horizons with no or little mottling. The soils of associated very poorly drained depressional areas are grayer, in places have weakly cemented subsoils, and are generally of the Rains or Plummer series. Caddo soils are like Pheba soils but without fragipan. The series differs from Lynchburg and Beauregard soils mainly in having a less clayey B horizon, it being clay loam versus sandy clay in Lynchburg and Beauregard soils. Caddo soils are extensive and widely distributed but are unimportant in the production of cultivated crops.

Soil Profile: Caddo very fine sandy loam

A_1 0-3" Light brownish-gray fine sandy loam; dark grayish-brown when moist; very weak granular structure; very friable;

soft, medium to strongly acid; gradual smooth boundary. 2 to 4 inches thick.

A_2	3-18"	Light gray very fine sandy loam; light brownish-gray when moist; slightly mottled with brown; structureless; very friable, hard; a few small concretions of iron oxide; very strongly acid; gradual smooth boundary. 10 to 20 inches thick.
B_{2g}	18-42"	Mottled yellow and light gray sandy clay loam; weak blocky structure; few to many fine pores; few thin patchy clay films; friable, very hard; very strongly acid; few mottles of yellowish-red in lower part; gradual boundary. 15 to 30 inches thick.
C_g	42-60"+	Mottled yellow and light gray heavy sandy ~~clay~~-loam or stratified clays, silts and sands; friable; moderately permeable; contains splotches and seams of yellowish-red: very strongly acid.

Range in Characteristics: Sandy loams and silt loams are the principal types but minor areas of loamy sands (which have subsoils of loam or sandy clay loam within 3 feet of the surface) occur. The A_1 horizon is less dark in cultivated areas. The A_2 horizon, which is everywhere at least slightly mottled with brown, is very pale brown in places transitional toward Bowie, especially in the western part of the series' range. In the wetter situations, the A_2 is weakly vesicular in its lower part. The mottled B_2 varies considerably in coloration within distances of a few feet, the range in proportion of yellow is from 25 to 75%, and a few reddish spots occur in places. A few small ferruginous concretions or ferromanganese concretions usually occur in all horizons and silt pockets may occur in the B and C horizons. Colors are for dry soil, except as otherwise indicated.

Topography: Level to very gently sloping marine terrace or erosional upland in the Gulf Coastal Plain. The gradient of the surface generally is less than 1% but minor areas occur on slopes of as much as 5% in places affected by seepage from sand hills.

Drainage and Permeability: Drainage is somewhat poor (imperfect). Surface runoff is very slow; internal drainage is medium except as inhibited by high ground water table which commonly is within the solum during cool moist seasons and 10 or 15 feet below the surface during the summer.

Vegetation: Originally densely forested.

CUTHBERT SERIES

The Cuthbert series consist of moderately well drained Red-Yellow Podzolic soils with low degrees of horizonation. These soils have developed in beds of marine clays, silty clays, and sandy clays that are highly stratified with lenses of sandy material. The Cuthbert soils are on gently sloping to steep upland areas primarily in association with Ruston, Ora, Shubuta, and Boswell soils, and to a lesser extent with the Susquehanna, Eustis, and Lakeland. They have thinner B horizons than Shubata and much thinner and finer textured B horizons than the Ruston and Ora, and lack the fragipan of the latter. Their subsoils are less sticky and plastic than those of the Boswell soils. Cuthbert soils are better drained, have more profile development, are less sticky and plastic, and are underlain by stratified materials (clays and sands) as compared to the Susquehanna soils that are derived chiefly from thick beds of massive and clays. The Cuthbert soils are extensive, occur in relatively large areas, but are not important agriculturally.

Soil Profile: Cuthbert fine sandy loam

A_p	0-6"	Dark grayish-brown fine sandy loam; weak fine granular structure; very friable; a few angular and rounded gravel 1/4 to 4 inches in diameter on the surface; many fine roots; very strongly acid; clear wavy boundry. 2 to 8 inches thick.
B_2	6-14"	Yellowish-red silty clay; moderate and strong fine and medium angular and subangular blocky structure; firm, slightly sticky, slightly plastic; few fine roots; very strongly acid; clear smooth boundry. 4 to 10 inches thick.
C_1	14-22"	Mottled yellowish-red, gray, pale brown, and yellowish-brown clay; massive; firm, sticky, plastic; few fine and medium roots; few ironstone fragments 1/4 to 1 inch in diameter; very strongly acid; abrupt wavy boundry. 5 to 12 inches thick.
C_2	22-72"+	Stratified thin beds of clay with lenses of sandy materials and discontinuous lenses of ironstone; clay beds are mottled red, gray, and brownish-yellow and sandy materials are reddish-yellow through light yellowish-brown; structureless; very strongly acid. Many feet thick.

Range in Characteristics: Principal types are fine sandy loam, sandy loam, and loamy fine sand. Minor types are very fine sandy loam, loamy sand, and sand. Gravelly, cobbly and flaggy phases are recognized. In many places thin platy ironstone or iron crust fragments are on the surface and in the profile. The amount and size of the fragments are extremely variable, ranging from none to many. Thick surface phases are recognized where A horizon averages more than 18 inches and less than 30 inches thick. Color of the A_p horizon ranges from grayish-brown through dark yellowish-brown. In uneroded areas the A horizon is very dark grayish-brown. A thin B_1 horizon is present in some profiles, ranging in color from pale brown through strong brown and in texture from loam through silty clay loam. Color of the B_2 horizon ranges from strong brown through red, texture from clay loam through clay. The B_2 may be faintly to distinctly mottled with pale brown and gray. The C horizon or underlying material is extremely variable, ranging from highly stratified thinly laminated strata of clays and sandy material to alternately interbedded tough clays and very friable loose sands and coarse sands. Colors given are for moist soils.

Topography: Gently sloping to steep uplands with slopes dominatly 10 to 25 per cent but ranging from about 5 to 40 per cent.

Drainage and Permeability: Moderately well drained. Runoff is medium to rapid; internal drainage and permeability are slow.

Vegetation: Dominantly hardwoods and some pines.

Series Established: Randolph County, Georgia, 1924.

MANTACHIE SERIES

The Mantachie series consists of somewhat poorly drained Alluvial soils. These soils are derived from recent alluvium washed chiefly from a large number of sandy to moderately fine textured soils of the Coastal Plain uplands. The Mantachie series is the somewhat poorly drained member of the drainage sequence that includes the well drained Ochlockonee; the moderately well drained Iuka, and the poorly drained Bibb series. Mantachie soils are also associated with the Urbo and Chastain soils in stream flood plains. Mantachie soils have gray mottles within 18 inches of the surface and commonly throughout the profile. The Bibb soils are grayer throughout the profile than the Mantachie soils. The latter are coarser textured than the Urbo and Chastain soils and also better drained than the Chastain soils. Mantachie soils are widely distributed, of large acreage, and are important to agriculture.

Soil Profile: Mantachie fine sandy loam

A_p 0-6" Brown fine sandy loam; weak fine granular structure; very friable; common fine roots; strongly acid; clear smooth boundry. 3 to 9 inches thick.

C_1 6-12" Brown sandy loam with common fine distinct mottle of light gray and light brownish-gray; weak fine granular structure; very friable; few fine roots; strongly acid; gradual smooth boundry. 5 to 12 inches thick.

C_{2g} 12-20" Mottled light brownish-gray, yellowish-brown and yellow fine sandy loam; structureless; friable; strongly acid; clear wavy boundry. 6 to 15 inches thick.

C_{3g} 20-45" Light gray sandy loam; structureless; very friable; few fine black concretions; few pockets and thin lenses of snady clay loam; strongly acid. 3 to 5 feet thick.

Range in Characteristics: Texture of surface layer is generally fine sandy loam but ranges from sandy loam to include silt loam and occasional silty clay loam or sandy clay loam on flood streams of larger streams. Stratification of sediments may be evident in any profile, with sand content dominating over silt. The A_p horizon ranges in color from very dark grayish-brown through brown or yellowish-brown. The C_1 horizon has a range in base color similar to that of the A_p horizon but generally is distinctly mottled with shades of gray and brown. It may lack a matrix color and be mottled gray; brown, and yellow or, rarely, be mottle-free. The C_{2g} horizon is mottled dominatly with shades of gray, yellow, and brown. Texture of the C_{2g} horizon ranges from silt loam to sandy clay loam. The C_{3g} horizon ranges in color from grayish-brown to distinctly mottled with shades of brown and yellow to include light gray, and the texture from silt loam through sandy clay loam. Pockets or strata of gravel may occur in the C_{3g} layer. A few or common fine ferromanganiferous concentrations may be present throughout the profile but occur chiefly in the C_{2g} and C_{3g} layers. Reaction of all horizons ranges from strongly acid to include medium acid. Colors are for moist soils.

Topography: Nearly level flood plain and upland drainage ways. Slopes range from 0 to 3 per cent.

Drainage and Permeability: Somewhat poorly drained with slow runoff and moderate to slow permeability. Generally subject to occasional overflow and may be subject to frequent flooding.

Vegetation: Mainly hardwoods but with some pine.

Series Established: Prentiss County, Mississippi, 1950.

SAWYER SERIES

Sawyer series consist of yellow Podzolic soils characterized by brownish-yellow friable upper subsoils and mottled red, yellow, and gray clay lower subsoils. Developed under forest from acid clays and sandy clays of the Gulf Coastal Plain.

Soil Profile: Sawyer very fine sandy loam

A_1	0-4"	Grayish-brown very fine sandy loam; weak medium granular; very friable; medium acid; grades into horizon below 3 to 6 inches thick.
A_2	4-14"	Very pale brown; very fine sandy loam; massive; porous; very friable; strongly acid; grades through thin transition to next horizon.
B_2	14-24"	Brownish-yellow light sandy clay faintly mottled with pale brown; moderate medium blocky; porous; friable; hard when dry; strongly acid; grades into horizon below.
B_3	24-40"	Mottled red; and light gray clay; massive; very firm; very sticky and very stiff; strongly acid; grades into horizon below.
C	40-70"+	Mottled light gray and reddish-yellow clay; massive and very slowly permeable; strongly acid.

Range in Characteristics: Fine and very fine sandy loams are the principal or only types, where cultivated, horizon is light brownish-gray and 5 to 8 inches thick. Horizon B_2 ranges from sandy clay loam to heavy sandy clay; parent material ranges from massive sandy clay to clay stratified with subsidiary sand.

Topography: Nearly level upland mostly with gradients of less than 2 per cent; sandy mounds occur in some areas.

Drainage and Permeability: Slow to moderate from surface; slow internally; the soil is successfully cultivated without artificial drainage.

Vegetation: Pine-oak forest in eastern, more humid part; mainly post oak and blackjack in western parts of range.

Series Established: Choctaw County, Oklahoma, 1937.

SUSQUEHANNA SERIES

The Susquehanna soils are in the Atlantic and Gulf Coastal Plains in the region of Red and Yellow Podzolic soils. These soils are derived chiefly from thick beds of acid heavy clays, and they are associated with and have developed from similar parent materials as the Boswell soils. The Susquehanna soils differ from the Boswell soils chiefly in that the clay underlying the surface soil is mottled to its top, whereas there is an unmottled layer just beneath the sandier surface soil of the Boswell soils. The Susquehanna soils differ from the Sawyer soils mainly in having thinner surface soils, heavier and more plastic mottled subsoils, whereas the Sawyer soils have yellowish unmottled and less plastic upper subsoils. The Susquehanna soils are also associated with a large number of other soils in the Coastal Plains but differ from most of them in having much finer textures and more plastic soil materials. In the western part of its geographic range, it is associated locally with the Lufkin soils which have grayer subsoils. The series is widely distributed and has a large total acreage but is of limited agricultural importance.

Soil Profile: Susquehanna fine sandy loam

1.	1/2-0"	Partly decomposed forest litter.
2.	0-2"	Dark gray (when dry); very friable fine sandy loam; weakly granular or nearly structureless; strongly acid. 1 to 4 inches thick.
3.	2-8"	Light brownish-gray (when dry); very friable fine sandy loam, almost structureless, passing quickly to underlying subsoil; strongly acid. 4 to 8 inches thick.
4.	8-30"	Highly mottled red, light gray, yellow, and reddish-brown very firm clay, very plastic and sticky when wet; very hard when dry; under normal moisture conditions medium to coarse blocky structure; strongly acid. 20 to 40 inches thick.
5.	30-50"	Transitional layer, the material ranging in structure and color from horizon 4 to horizon 6. Strongly acid.
6.	50"+	Light gray massive heavy clay or very fine sandy clay mottled or streaked with yellow, yellowish-red, or yellowish-brown.

Range in Characteristics: Principal types in this series are fine sandy loam, sandy loam, sandy clay loam, and clay. Under cultivation horizons 1, 2, and part or all of 3 lose their identity. Over extnesive areas erosion has removed all or part of the sandy material to expose the mottled clay at the surface or have it mixed into the furrow slice. In the western less humid part of the series range the acidity of horizons 1 and 2 is medium. Most of the substrata are strongly acid to a depth of many feet but alkaline or calcareous substrata may occur at depths below 6 feet where Susquehanna soils adjoin areas of Oktibbeha and related soils. Locally the substrata at depths of 6 to 8 feet consist of thin layers of light gray heavy clay and yellowish-brown very fine sandy clay. Scales of mica may occur in these layers and locally formed iron crusts may be found. The relative proportions of the several colors in horizons 4, 5, and 6 cover a wide range. In some places the lower horizons is dominantly gray and in other places it is prevailingly red or reddish-brown. Colors given for moist soils unless otherwise stated.

Topography: Predominantly undulating to hilly uplands with slopes ranging from 5 to 20 per cent, but there are some nearly level areas with slopes of 1 to 5 per cent. The extreme slope range is from 0 to 30 per cent.

Drainage: Imperfectly drained with moderate to rapid external and very slow internal drainage.

Vegetation: Pine-hardwood.

Series Established: Cecil County, Maryland, 1900.

VITA

Eugene Frank Hastings was born near Boyce, Louisiana in Grant Parish on November 6, 1928 and lived within a nine mile radius of Boyce until graduation from Boyce High School in May, 1946. He became a Christian at the age of 11. He enlisted in the Air Force Branch of the U. S. Army upon completion of high school, and in 1949, he received an honorable discharge with a rank of S/Sargent.

At the beginning of the fall semester of 1949, he enrolled in Louisiana State University and four years later received a B. S. degree in Forestry. He was accepted by the L. S. U. Graduate School for the fall semester of 1953 and received the degree of M. S. in Game Management in 1954. He accepted an invitation to join the Alpha Zeta and Xi Sigma Pi fraternities while in the College of Agriculture.

He obtained employment with the Louisiana Wild Life and Fisheries Commission after completing college. Nine months later he resigned from the Commission and began working with the U. S. Rubber Company in their Baton Rouge, Louisiana plant.

He left the U. S. Rubber Company in 1962 to reenter graduate school and is now a candidate for a Ph.D. degree in Forestry with a Wildlife Management minor.

On August 14, 1954, he married Elizabeth Rogers of Centreville, Mississippi. They have one son who was born on August 20, 1959.

EXAMINATION AND THESIS REPORT

Candidate: Eugene Frank Hastings

Major Field: Forestry

Title of Thesis: Yield and Chemical Analyses of Fruit Produced by Selected Deer-Browse Plants in a Loblolly-Shortleaf Pine-Hardwood Forest

Approved:

Bryant A. Bateman
Major Professor and Chairman

Max Goodrich
Dean of the Graduate School

EXAMINING COMMITTEE:

Paul Y. Burns

Olen A. Brown

Leslie L. Glasgow

Thomas Hansbrough

Date of Examination:

July 5, 1966